CHAPTER 02

Ethnoveterinary Medicine for Gastrointestinal Parasitism in Goats

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SUMMARY

Small ruminants are the backbone of rural communities as it serves as a source of food and income. The major challenge to smallholder farmers is the high prevalence of parasitic diseases since they are mainly reared in an extensive system. Ethnoveterinary medicine (EVM) deals with the application of traditional beliefs, knowledge, and practices to veterinary medicine, which is often associated with conventional wisdom, skills, methods, and practices that are transferred from generation to generation. Globally, the use of indigenous knowledge in conjunction with modern veterinary medicine as a remedy for parasitic diseases is well acknowledged by most farmers. In various countries, for the treatment of nematode parasite infections such as *Strongylus*, *Parascaris*, and *Ascaris* spp., leaves, dried flowers, and oil of certain plants are used like *Nicotiana tabacum*, *Azadirachta indica*, *Annona squamosa*, and *Aloe latifolia*, etc. The anthelmintic properties in these plants are due to certain substances that principally have activity against parasites whereas in some plants it is due to their secondary products like saponins, alkaloids, non-protein amino acids, tannins, and other polyphenols, lignins, glycosides. The exploration in the field of EVM is of major significance, as most of the farmers are unaware of vaccination and deworming of the animals and are inexperienced with systemic therapy. EVM has emerged as low-cost alternatives to allopathic drugs, so they are more likely to be used by peasant farmers to cure their livestock. Hence, the practice of EVM for the control of parasites is an important intervention for improving animal productivity.

INTRODUCTION

Ethnoveterinary medicine (EVM) deals with the application of traditional beliefs, knowledge, and practices to veterinary medicine, which is often associated with conventional wisdom, skills, methods, and practices that are transferred from generation to generation (Khan et al., 2019). Globally, the use of indigenous knowledge in conjunction with modern veterinary medicine as a remedy for livestock diseases is well-acknowledged by most farmers. It has emerged as a low-cost alternative to allopathic drugs, hence they are used by peasant farmers to cure their livestock (Mizaei-Aghsaghali, 2012). The exploration in the field of ethnoveterinary medicine is of major significance, as most of the farmers are unaware of vaccination and deworming of the animals (Moreki et al., 2010) and are inexperienced with systemic therapy.

Livestock predominantly small ruminants are the backbone of rural-based communities as it serves as a source of food and income (Djoueche et al., 2011). The major challenge to smallholder farmers is a high prevalence of livestock diseases in their reared animals. Tyasi & Tyasi (2015) reported that most smallholder farmers, practice extensive feeding systems by utilization of natural vegetation but this practice leads to exposure of livestock to various internal parasites present in contaminated pastures. Internal parasitism is a prime issue of concern among smallholder livestock farmers. These parasites restrict livestock productivity by exerting a negative impact on their fertility, leading to skin inflammation and sucking their blood, ultimately leading to their death (Roeber et al., 2013).

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Hence, the practice of using ethnoveterinary medicines for the control of parasites is an important intervention for improving animal productivity.

NEED FOR ETHNOVETERINARY MEDICINE

Strategies currently in use for the control of gastrointestinal parasites largely rely on the repeated use of synthetic anthelmintic drugs, which is associated with several challenges such as the development of resistance to the drugs (Tsotetsi et al., 2013), polluting the environment, causing chemical residues in meat and milk (Jeyathilakan et al., 2012), in addition to their high costs and low availability.

In view of these challenges, several researches have been conducted on plant species that can come up as alternative anthelmintic drugs to preside over gastrointestinal infections in livestock. Some researchers have also reported that the use of medicinal plants is safe, sustainable, and is environmentally acceptable (Shen et al., 2010), their cost is comparatively less and they perceived to have better effectiveness as compared to that of synthetic drugs (Luseba et al., 2007). In addition to this, due to the presence of various active principles that in combination act synergistically, resulting in the anthelmintic effect and restricting the development of resistance (Fouche et al., 2016).

USE OF ETHNOVETERINARY MEDICINES ON GLOBAL STAGE

Worldwide, the uses of plant-derived ethnoveterinary medicines as anthelmintic drugs have been reported. In the United Kingdom, for the treatment of nematode parasite infections such as *Strongylus*, *Parascaris*, and *Ascaris* spp., leaves, dried flowers, and oil of chenopodium, which is derived from *Chenopodium ambrosioides*, have been reported to be used for many years (Guarrera, 1999). Additionally, in ruminants and poultry, male fern *Dryopteris filix-mas* and *Artemisia* spp. plants have been used against cestodes such as Moniezia spp., and nematodes, such as *Ascaridia* spp., respectively (Codex, 1965).

In Katanga province, the Democratic Republic of Congo, nine plant species have been recognized, to be commonly used to treat gastrointestinal parasitic infections, one of them is *Vitex thomasii* (Kikoto muchi), family name Verbenaceae, which is commonly used (Embeya et al., 2014). Djoueche et al. (2011) reported *Anogeissus leiocarpus* and *Gardenia ternifolia* to have the potential to be used to treat intestinal worms in sheep and goats.

In Kenya, tribal people of the Meru community have explored the anthelmintic potential of several plants such as *Aloe latifolia, Azadirachta indica, Commiphora eminii, Crotalaria laburnifolia, Kigelia africana, Olea europaea, Solanum incanum* and *Warburgia ugandensis* (Wanzala, 2012).

South African rural smallholder livestock farmers have developed their own approach to controlling internal parasites through the use of indigenous plants, namely, *Aloe ferox, Aloe arborescens, Acokanthera oppositifolia, Elephantorrhiza elephantina, Albuca setosa, Centella coriacea, Bulbine latifolia, Teucrium trifidum, Strychnos henningsii, Leonotis leonurus, Cleome gynandra, Maerua angolensis*, and *Monsonia angustifolia* (Sanhokwe et al., 2016).

In Nigeria, Fulani people involved in animal rearing and relying on them as their sole source of income, have been involved in the treating of their animal diseases years before the onset of modern medicine (Nwude, 1986), in particular, they have used several plant-based remedies against gastrointestinal parasites (Ibrahim et al., 1984). The ability of *C. papaya* leaves, to exert its effect on the bacterial and parasitic cells is due to the presence of papain and consequently, can be used as an anthelmintics and antibiotics. Adeola et al. (2015) reported that 2g/kg of *Vernonia amgydalina* and 1g/kg of *Talinum triangulare* showed a decrease of 91.6% and 69% in the mean egg per gram (EPG) output of the fecal sample, indicating that them to be used as antihelmintic plants to treat goat parasitic diseases and thus helping to improve the health status of the goat.

Saimo et al. (2003) performed a survey in poultry and goat areas in north and central Uganda and documented several medicinal plants used to treat coccidiosis and helminthosis including blood-sucking parasites such as *Haemonchus* and *Bunostomum*.

MODE OF ACTION OF PLANTS EXHIBITING ANTHELMINTIC ACTIVITY

The anthelmintic activity has been reported in some plants although the mechanisms of action are yet to be explored. In various plants, it has been reported that by their inclusion in the diet of the animals, the immune response is accelerated against the parasites, due to adequate nutrient supplementation (Athanasiadou & Kyriazakis 2000). In concurrence with this, Houdijk et al. (2001) also concluded that in ruminants, incorporation of good quality protein in the diet of animals boosts their immune response against parasitic infection. In many plants, the anthelmintic properties are due to certain substances that principally have activity against parasites whereas in some other cases, anthelmintic activity present in the plant is due to plant secondary products, which are products that are not directly involved in the growth of the plants but are

present in the plants to protect them from being eaten by animals (Mueller-Harvey and McAllan, 1992).

Secondary plant products include saponins, alkaloids, non-protein amino acids, tannins, and other polyphenols, lignins, and glycosides, and some of them have been considered to be responsible for the anti-parasitic effect of plants. For example, garlic contains a sulphuric compound, responsible for its anthelmintic effect, on the other hand, naphthoquinone, a phytocompound present in the walnut, is reported to have anthelmintic activity against the worms (Guarrera, 1999). Jain et al. (2013) reported that the phytochemicals found in plants, independently or interdependently may block tubulin polymerization and inhibit glucose uptake of parasites and this inhibition in turn affects feed intake and sustenance of the parasites leading to mortality of parasites. Some phytocompunds cause damage to the mucopolysaccharide membrane of worms inducing damage to the external layer of the worm which severely restricts their motile activity and which in turn is known to cause paralysis and eventually results in the death of the parasite (Jain et al., 2013).

Akhtar and Ahmad (1992) reported that the *Mallotus philippinensis* plant contains glycosides which is active phytocompound attributing to its good results against the cestodes in goats. Likewise, Hoskin et al. (1999) reported that the anthelmintic activity of chicory is due to the presence of terpenoids or phenolic compounds, such as sesquiterpene lactones and coumarins respectively which are present in the plant. Among various phytocompounds that have been reported to have anthelmintic properties, condensed tannins are one of the essential phytocompounds. Taylor and Murant (1966) conducted *in vitro* study on aqueous extracts from the roots and stems of raspberries, which are rich in condensed tannins, and reported that it significantly decreases the number of the plant nematode *Longidorus elongatus* in time and dose-related manner.

Furthermore, some researchers performed studies on various plants to analyze purified condensed tannins *in vitro* to examine their activity against gastrointestinal nematodes of sheep and goats such as *Trichostrongylus colubriformis* and *Teladorsagia circumcincta* (Molan et al., 2000 a,b) and concluded that condensed tannins have detrimental effect on their third stage larvae, as it causes significant reduction in the viability, motility and migration ability of larvae of the gastrointestinal nematodes. In the same manner, quebracho extract is available in the market for small ruminants, having its main constituent as condensed tannins, and being accountable for its anthelmintic activity (Paolini et al., 2003). It was reported that on the administration of quebracho extract, there was a 50% reduction in the egg per gram and in the number of adult worms retrieved from the small intestine of sheep in addition to this, a reduction in fecundity of abomasal nematodes was also reported in goats. Tiwari et al. (2011) concluded that the anthelmintic activity of tannins against helminths is exclusive because of their protein-binding action, by which the worms get devoid of dietary protein, provoking their malnourishment which ultimately results in the mortality of helminths.

Subsequent to tannins are alkaloids phytocompounds, which have an impact on the central nervous system of worms sequentially leading to paralysis in the worm (Roy et al., 2010), this action is exerted by various secondary plant metabolites such as steroidal alkaloids and oligoglycosides, which inhibits the exchange of sucrose in the gastrointestinal tract. They are also known to have an antioxidant effect, which interferes with homeostasis which is crucial for the growth of the worm (Vadivel & Panwal 2016). Another phytocompound is bromelain, obtained from pineapple trees, particularly from the stem, which acts on the cuticle of parasites and is proteinase in nature, which results in the removal of the cuticles and ultimately killing the worms by causing damage to their outer covering (Stepek et al., 2007).

Besides these phytocompounds, there are certain essential oils that have been reported to have potent anthelmintic activity such as the oil of *Eucalyptus staigeriana* (Macedo et al., 2010) and *Juniperus pinchotii* (Armstrong et al., 2013). The anthelmintic activities of these phytocompounds have been associated with the presence of terpenoids (lemonene, eugenol, carvacrol, and citral), which are the chemical compounds, exerting their effect either by inhibiting the growth or reducing the fecundity or altering the proper development process of the parasite (Zhu et al., 2013).

Briefly describing the mechanism of action of various phytocompounds, attributing to their anthelmintic activity. Saponins alter the permeability of the cell membrane of the parasite, resulting in vacuolization and deterioration of the teguments of the parasite. Benzyl isothiocyanate causes the inhibition of energy metabolism and affects the motor activity of the parasite. Cystiene proteinases, plant cystiene, proteinases, papain, and cymopapain have high proteolytic activities that result in the digestion of nematode cuticles. Isoflavones restrict glycolysis and glycogenolysis, by inhibiting the enzymes involved in the mechanism and also disturb the calcium homeostasis and NO activity in the parasite. Phenolic compounds restrict the energy generation mechanism by uncoupling the oxidative phosphorylation and interfering with the glycoprotein of the cell surface of the parasite resulting in the death of parasites. Alkaloids work on the central nervous system and cause paralysis of the worms. It also reduces nitrate generation and causes interference with homeostasis essential for the development of helminths.

In recent times, emphasis has been given to the potential anthelmintic properties of certain grazing forages, such as forages like *Lotus* spp., *Hedysarum* spp., *Onobrychis* spp., and *Cichorium intybus*. These are reported to be nutritious forages as well and these also have abundant amounts of condensed tannins or other phytocompounds, so their ingestion can result in good performance of animals along with its anthelmintic effects. Hence, they are considered the ideal candidate for alternatives to parasite control in ruminant production systems.

For further clarification to this Niezen et al. (2002) conducted a study, on sheep being grazed on tannin-rich forage i.e. *Hedysarum coronarium* (sulla), and the control group sheep were grazed on low tannin forage i.e. *Medicago sativa* and reported that significantly good productivity along with the lesser burden of *T. circumcincta* and *T. colubriformis* was found in sheep being grazed over tannin-rich forages as compared to sheep of control group. In another study, Robertson et al. (1995), concluded that gastrointestinal nematode infection in sheep grazing on *Hedysarum coronarium* was found to be significantly lower compared to sheep grazing on other forages along with the amelioration in their growth and well-being (Coop et al., 1982).

GASTROINTESTINAL PARASITES OF GOATS AND PLANTS USED FOR THEIR CONTROL

The prevalent parasites causing helminthosis in goats include *Trichostrongylus* spp., *Trichuris* spp., *Bunostomum* spp., *Haemonchus* sp., *Oesophagostomum* spp. and *Ostertagia* spp. (Kumar et al., 2013). Among these parasites, *Haemonchus* gravely compromises goat growth and development and leads to severe economic loss through the huge mortality of affected animals (Roeber et al., 2013). Adhikari et al. (2017) reported that infection with *Haemonchus contortus*, is characterized by severe anemia and causes high mortalities in kids.

The substantial factors resulting in helminthiasis include poor management which comprises of poor quality feeds offered to animals, poor housing facilities, lack of parasite and disease control measures, and convenient habitats that favor the growth of the parasites, such as ambient conditions that enhance the multiplication of the parasite (Belina et al. 2017).

These gastrointestinal parasites exert their effect directly by affecting the host by disturbing their metabolism, feeding on their blood, and causing damage to their intestinal wall (Hughes et al., 2009). These are in turn also responsible for low food conversion ratio, low food absorption by the intestinal wall, and reduced appetite (Foreyt, 2001). Moreover, these parasitic infections lead to economic losses as they cause a decrease in growth rate and reproduction (Stien et al., 2002) as well as resulting in a compromise of the immune status of the host and in turn making them prone to harmful pathogens (Rashid et al., 2016). *Heamoncus (H.) contortus* exerts an unparalleled threat to the farm animal and sucks blood (approximately 0.05 ml blood per worm per day) from the abomasum of the host (Tak et al., 2013).

Eguale and Giday (2009) conducted an *in vitro* study to ascertain the feasible anthelmintic effects of crude aqueous and hydroalcoholic extracts of the leaves of *Chenopodium ambrosioides*, *Lawsonia inermis* and seeds of *Jatropha curcas*, on eggs and adult *H. contortus* worm. They performed an egg hatch assay and found that extracts of both *C. ambrosioides* and *J. curcas* significantly inhibited the hatching at a concentration less than or equal to 2 mg/ml, while the effect of *L. inermis* did not inhibit the hatching of eggs of *H. contortus*, significantly, at all tested concentrations. They also conducted an adult mortality test and concluded that extracts from *C. ambrosioides* have a moderate effect, while *J. curcas* and *L. inermis* have statistically no significant effect on the survival of adult parasites ($P < 0.05$).

Martinez-Ortiz-de-Montellano et al. (2013) conducted *in vitro* study with *Lysiloma latisiliquum* and *Onobrychis viciifolia*, which are rich in tannins and reported that on exposure of *H. contortus* to the extract of *L. latisiliquum* and *O. viciifolia*, made in acetone: water (70:30), causes detrimental changes in morphology of the parasite, altering their internal folds and making their cuticle thicker. These extracts also accumulate their internal material in the buccal capsule and anus or vulva region of the parasite. This alteration in the cuticular structure of the parasites hinders the motility of nematodes and alterations in the buccal capsule disrupt parasite nutrition and consequently lead to malnutrition, reduced fertility, and mortality.

Some researchers have studied the *in vitro* efficacy of *Nauclea latifola* against strongyle nematodes of small ruminants by performing egg hatch assay, the results of the extracts at 100 mg/ml concentration were comparable with commercial anthelmintic drug, levamisole, and albendazole and concluded it to have good anthelmintic potential (Onyeyili et al., 2001). Some of the extracts, which were rich in sesquiterpene lactones of two forage chicory (*Cichorium intybus*) showed inhibition of hatching of a predominantly *H. contortus* egg population, as its action is associated with the presence of α-methylene-γ-lactone functional group capable of reacting with sulfhydryl proteins (Foster et al., 2011). Ketzis et al. (2002) conducted *in vitro* test by using *Chenopodium ambrosioides* and its essential oil for the treatment of *H. contortus* and mixed nematode infection in goats and reported that oil causes the reduction in the viability of eggs and concluded it to be beneficial to reduce parasite loads. Iqbal et al. (2001a) have reported that methanol extracts of *Allium*

sativum, *Zingiber officinale*, *Curcurbita mexicana*, and *Ficus religiosa*, possess varying degrees of *in vitro* anthelmintic activity and *Zingiber officinale* even killed *H. contortus* worms within 2 hours (h) post-exposure thus being 100% effective. Extracts of sorghum delayed the hatching and development of eggs of *H. contortus* at lower concentrations and proved lethal at higher (>5-10%) concentrations (Iqbal et al., 2001b).

The ethanolic extract of *Khaya senegalensis*, *Amaranthus spinosus*, and *Heliothropium indicum* produced a significant reduction in mean eggs per gram feces of trichostrongylids comparable to the effect of ivermectin (Okpara et al., 2004). Chiezey et al. (2000) reported that *Khaya senegalensis* and *Vernonia amyddalina* showed moderate to high efficacy against *Haemonchus*, *Cooperia*, *Oesophagostomum*, and *Trichostrongylus species* of helminths. Assiak et al., (2002) found that the leaves of *Amaranthus spinosus* elicit over 80% reduction in eggs per gram feces of trichostrongylids in sheep and goats. The aqueous extract of the papaya seed showed over 90% efficacy against gastrointestinal parasites of goats mainly *Oesophagostomum, Trichuris, and Tricostrongylus* (Fajimi et al., 2001).

Sunandhadevi et al. (2017) evaluated the efficacy of a herbal formulation containing crude powder of seeds of *Vernonia anthelmintica* (kalazeera), *Artemisia maritime* (Kirmaniova), *Butea frondosa* (palash) and stem bark of *Holarrhena antidysentrica* (kutaja) in equal quantities against gastro-intestinal nematodes in goats @ 5,7.5 and 10gm/ animal/PO, for 10 days respectively and concluded that this formulation to be most effective at 7.5 gm dose followed by 10gm, orally. Gupta et al. (2017) evaluated the anthelmintic efficacy of herbal formulation containing crude aqueous extract of leaves of *Azadirachta indica* and *Nicotiana tabacum* flower of *Calotropis procera* and seeds of *Trachyspermum ammi* @ 2, 3 and 4 gm/kg body weight orally, in goats naturally infected with gastro-intestinal nematodes and reported 42, 52 and 70% reduction in egg per gram on 30th day respectively. Dixit et al. (2019) evaluated the efficacy of an aqueous extract of *Nicotiana tabacum*, *Azadirachta indica*, and *Annona squamosa* leaves @ 1gm and 1.5 gm/kg body weight orally against fenbendazole-resistant *Haemonchus contortus* and reported that extract showed no conspicuous reduction in post-treatment (10 days) fecal egg count.

CHALLENGES IN THE APPLICATION OF ETHNOVETERINARY MEDICINES

In spite of various assets associated with the application of ethnoveterinary medicines, there are some challenges related to it such as improper diagnosis of the disease, incorrect medicinal doses, unhygienic practices for the preparation of the plant-derived medicaments, risk of toxicity associated with its use and lack of knowledge to use ethnoveterinary medicines to drive its full potential (Thillaivanan and Samraj, 2014). In addition to this, the use of ethnoveterinary medicines is limited by certain localities or vicinity thus leading to poor distribution of information concerning these remedies. Along with this, most of the ethnoveterinary medicines are derived from indigenous plants, and so their use creates the risk of habitat destruction and loss of vegetation (Yirga et al., 2012).

One of the major challenges in the use of ethnoveterinary medicines is the risk of possible toxicity associated with it as most grazing animals are susceptible to the toxic effects of plant secondary metabolites when they have crossed their threshold of daily intake. Lastly, the practice of ethnoveterinary medicine practices is largely based on the verbal discussion of information between generations, but the lack of proper record-keeping leads to the abolition of such indigenous knowledge (Gurib-Fakim, 2006).

DEVELOPING PERSPECTIVE OF ETHNOVETERINARY MEDICINE

Ethnoveterinary medicine (EVM) deals with the application of traditional beliefs, knowledge, and practices to veterinary medicine, which is often associated with conventional wisdom, skills, methods, and practices that are transferred from generation to generation. Broadly, the prime aim of research in EVM is that peasant farmers can utilize their locally available plants for treating their animals. Additionally, it contributes to the use of new phytocompounds, used to treat animals and also aids in reducing the resistance pressure, and lastly, it also has a crucial work in the conservation of a variety of species of useful plants found on the surface of the earth.

Due to paramount apparent efficiency of plant-derived ethnoveterinary remedies in management of internal parasites and ethnoveterinary medicines is gaining attention in goats. However, there is inadequate information on the potential activity and effects of these plant-derived ethnoveterinary medicines on the gastrointestinal integrity and immunity of the farm animals as well as on the products obtained from them such as meat or milk quality. Several studies to determine the efficacy and determine toxicity of these plant-derived are a necessary and suggested for further research to perceive activity of ethnoveterinary medicines.

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