EFFICACY OF GARLIC (*Allium sativum*) AS AN ANTHELMINTIC IN DJALLONKE GOATS

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ABSTRACT
An increase in the anthelmintic resistance of parasites in small ruminants and a push towards non-chemical farming necessitate the search for alternative forms of anthelmintic. The present study was carried out to evaluate the effectiveness of garlic (Allium sativum) extract for controlling gastrointestinal tract (GIT) parasites in goats. One hundred and twenty West African Dwarf goats were involved, 60 each of young and adult goats. Three doses (2.5 ml, 5ml and 10 ml) of garlic extract, positive (albendazole) and negative (distilled water) controls were administered to equal numbers of young and adult goats. The overall infection rate of GIT parasites was 84%, and goats were equally (p>0.05) infected with strongyle spp. Eimeria spp. and tapeworm within the guinea savannah environment. Garlic extract at 5 ml and 10 ml doses were effective in reducing faecal egg counts (FECs) of strongyles spp. (p<0.05), tapeworm (p<0.05) and overall GIT parasites (p<0.05) populations. Similarly, all doses of garlic extract used were effective in reducing Eimeria spp. Garlic extract at 5 ml dose significantly (p<0.05) reduced Eimeria spp. and overall GIT parasites FEC in adult than in young goats. Garlic extract as an oral anthelmintic in goats is a viable option to commercially available chemicals, and 5 ml and 10 ml doses were effective in reducing the FECs of all the species of GIT parasites studied.

Keywords: *Djallonke goats, garlic extract, GIT parasites, efficacy, faecal egg counts*

INTRODUCTION
Sheep and goats harbour a variety of gastrointestinal tract (GIT) parasites, many of which are shared by both species. Among these parasites, helminths are the most important that affect the growth (Singh *et al*., 2015) as well as production (Zhong *et al*., 2015) of farm animals. Gastrointestinal tract nematodes of *Trichostrongylidae* family are perhaps the most important parasites of small ruminants world-wide, causing significant morbidity and loss of production (Pawel *et al*., 2004). Parasites of livestock cause diseases of major socio-economic importance worldwide. The financial and agriculture losses caused by parasites have a substantial impact on farm profitability. For example, the annual cost associated with parasitic diseases in sheep and goats in Australia was estimated at 1 billion dollars (Sackett and Holmes, 2006), and are proposed to be tens of billions of dollars worldwide, based to the sales of anti-parasitic compounds by pharmaceutical companies, excluding production losses (Sackett and Holmes, 2006). Thus, there are major economic gains to be made in agriculture by enhancing the control of key parasitic diseases.

Traditionally, producers have used commercially available anthelmintic (benzimidazoles, imidazothiazoles-tetrahydropyrimidines and avermectins-milbemycins) to control parasites. Even with optimally timed strategic treatments, this type of control is expensive, and in most cases, only partially effective (Veale, 2002). Additionally, an increase in the anthelmintic resistance of parasites is currently a serious threat, and research is being done to find alternative forms of anthelmintic (Shalaby, 2013). The societal push towards non-chemical (eco-friendly, green, organic) farming has also hastened the search for viable alternatives to chemical anthelmintic (Waller and Thamsborg, 2004). Development of anthelmintic resistance in helminths reported in a number of countries gives a clear indication that control programmes based exclusively on anthelmintics use are not sustainable (van Wyk *et al*., 1997).

Medicinal plants have served through ages as a constant source of medication for of a variety of diseases. The history of herbal medicine is almost as old as human civilization. Plants are known to provide a rich source of botanical anthelmintic, antibacterial and insecticidal effects (Satyavati *et al*., 1976). Garlic (*Allium sativum*) has been used medicinally worldwide for many centuries (Sunita *et al*., 2013). In Chinese herbal medicine, it is used to prevent influenza, relieve toxicities and kill parasites such as roundworms and tapeworms (Bensky and Gamble, 1993). Today, garlic is used as a home remedy for diverse health problems such as common cold, toothache, earache, nausea, high blood pressure, and for treatment of cancer and other chronic diseases (Brown and Marcy, 1991). *A. sativum* has been reported to be a parasiticide, amebicide, acarifuge, vermifuge, larvicide, fungicide, and immuno-stimulant besides other properties (Duke, 2002). Anthony and associates (2005) reported that *A. sativum* influences the growth of at least 12 different human and nonhuman parasites, and has immunomodulatory activity. Garlic has been used to treat animals that suffer from GIT parasitism (Guarrera, 1999), and availability, improved animal health, and comparable cost to commercial preparations have been cited as attributes that make garlic attractive to producers (Worku *et al*., 2009).

There are a few studies on the efficacy of common dewormers used on the field for prophylactic and therapeutic purposes. Similarly, little research has been directed at resistance against these dewormers (Kaplan and Vidyashankar, 2012; Mavrot *et al*., 2015; Rose *et al*., 2015; Glover *et al*., 2017; Sangster *et al*., 2018; Charlier *et al.*, 2018). There are, however, inconsistent results on the effect of garlic on GIT parasites. While some authors (Sutton and Haik, 1999; Worku *et al*., 2009) reported no effect of garlic on some GIT parasites in donkeys and goats, other studies found effective control against other GIT parasites (Toulah and Al-Rawi, 2007; Worku *et al*., 2009; Massamha *et al*., 2010). There is limited information on the effects of host age and sex on the efficacy of garlic on strongyles, tapeworm and coccidia. Additionally, it is not clear at what dose garlic extract will have a better efficacy on these GIT parasites. The present study, therefore, sought to evaluate the effects of host sex, age and garlic extract dose on the efficacy of garlic extract on faecal egg count (FEC) for strongyles, tapeworm and *Eimeria spp.* in Djallonke goats.

MATERIALS AND METHOD

Study **area**

The research was conducted at the Savelugu Sheep and Goat Disease Investigations Farm of the Veterinary Services Directorate. Savelugu is located in the Savelugu municipality of the Northern region of Ghana (latitude 9º 40’ N; longitude 0º 49’ W). The annual rainfall pattern is erratic at the beginning of the season in April, and intensifies as the season advances, raising the annual average from 600 mm to 1000 mm. The minimum, average and maximum temperatures are 16°C, 34°C and 42°C, respectively. The low temperatures are experienced from December to late February due to the influence of the North-East Trade winds (Nyadzi, 2016). The district is located in the Savannah woodland, and could sustain large scale livestock farming as well as the cultivation of food crops such as rice, groundnuts, yam, cassava, maize, cowpea and sorghum. The trees found in the area include *Vitellaria paradoxa* and *Parkia bigblobosa,* which are drought resistant, and are mostly of economic value.

Experimental animals and management

The experiment was conducted using West African Dwarf goats also known as the Djallonké goats. A total of 120 goats, comprising 60 each of young (< 1 year) and adults (> 1 year) were involved in the study. Also, 60 each of males and females were involved. Age categorization into young and adult was done based on the approach previously used by Steele *et al*. (1996) in goats, whiles their ages were estimated by dentition (Abegaz and Awgichew, 2009).

Animals were kept under the semi-intensive system of management. Goats were housed in a concrete structure with aluminum roofing, and a raised floor 30 cm above the ground, and an open yard of about 100 m perimeter attached. Animals are sent out for grazing on communal pasture at 9:00 am and return between the hours of 4 and 5 pm during the dry season. They mostly graze on *Aspillia africana and Centrocema pubescens*. During the rainy season, however, they are limited to paddocks on the farm. Supplements are mainly hay and leaves from tall trees. No special breeding programme is followed, except that when a female is noted to be on heat, it is introduced to a male. During the third trimester of pregnancy, does are separated until delivery. Lactating and sick does are kept in separate pens. Males and females are also kept separately. Veterinarians are called in the event of a suspected disease or parasitic infection, and they are treated mainly through chemotherapies. However, all the animals used were not on any commercial anthelmintic programme for the period.

Experimental procedure

Garlic preparation and treatment of animals

Garlic suspension was prepared by homogenizing garlic cloves (from matured garlic plants) using a sterile earthenware and a pestle. The paste obtained was transferred into a sterile beaker. A measuring cylinder was then used to measure desired volumes of the concentrated garlic paste into falcon tubes. Calculated volumes of distilled water were then added to make suspensions, which were used as drench.

Animals were grouped into five, each group comprising 12 each of young and adult goats. Each group also comprised 12 each of males and females. Groups 1, 2 and 3, each received garlic paste concentrate at the rate of 2.5 ml, 5 ml and 10 ml, respectively, and each was diluted in distilled water to make a 30 ml volume. Group 4 received albendazole at a concentration of 2.5 ml and a dosage of 0.5 ml/kg body weight, while group 5 received 30 ml of distilled water.

Collection of faecal samples

Approximately 3 grams of faecal sample was collected directly from the rectum of each goat into a vial. First set of samples were collected prior to treatment, while a second set were collected two weeks following treatment. These faecal samples were labeled and refrigerated (4° C) until they were processed. Refrigerated samples were processed within 7 days based on the recommendations of Nielsen *et al.* (2010). All procedures used were approved by the University for Development Studies Institutional Review Board.

Analysis of faecal samples and ova count

Faecal samples were analysed for helminthic eggs by the Salt Flotation Technique previously described by Ijaz *et al*. (2009). Forty-five milliliters of tap water was added to 3 grams of faecal sample in a container and thoroughly mixed with a stirrer. The resultant faecal suspension was then transferred into a test tube and centrifuged at 7000 rpm for 3 minutes at room temperature, to establish two layers. The supernatant fluid was then poured off and the tube filled to 3 ml with NaCl solution, well stirred and centrifuged again at 7000 rpm for 3 minutes. The supernatant fluid was sampled onto the McMaster counting chamber using Pasteur pipette. The transferred fluid was then allowed 5 minutes to settle and then examined under a microscope at ×10 magnification. All eggs within the engraved area of both chambers were counted.

Egg count per gram (EPG) of faeces were determined using the McMaster Technique, and previously described by Soulsby (1982). The McMaster counting technique is a quantitative technique for determining the number of eggs present per gram of faeces. All faecal counts were carried out in duplicates. Duplicate counts were checked for precision using Poisson distribution (Bowman, 1995).

Statistical analysis

Data were evaluated for normality of variance and homogeneity using the Shapiro-Wilk's W and Levene's tests, respectively. Variances were not homogenous except for species differences in pre-treatment GIT parasites FEC in goats. Differences in the pre-treatment FECs of the various species of GIT parasites found in Djallonke goats were determined using the general linear model, while the effects of garlic extract dose, host sex and age, on the efficacy of garlic extract were established using Kruskal-Wallis test/ Mann Whitney U test. All comparisons were done at 5% level of significance.

Pre-treatment prevalence rate for GIT parasites was estimated as the percentage of animals carrying GIT parasites to the total population of animals inspected for GIT parasites before treatment (number of animals carrying GIT parasites/ total population of animals inspected for GIT parasites x 100) (CDC Web Archive, 2022). Efficacy for a particular garlic extract dose was estimated using the formular: Efficacy (%) = 100 x (1- Post treatment egg counts/Pre-treatment egg counts) (Montresor, 2011; Vercruysse *et al.,* 2011).

RESULTS

The pre-treatment prevalence rate of GIT parasites in Djallonke goats in this study was 84%. The FECs for GIT parasites in these goats is shown in Figure 1. Even though Eimeria spp. egg count per gram (EPG) of faeces tended to be higher than both tapeworm and strongyle's EPG of faeces, the differences among the three species were not statistically significant ($p>0.05$). Garlic extract at 5 ml and 10 ml doses had higher ($p<0.05$) efficacies on tapeworm than 2.5 ml dose. These efficacy levels were similar to that recorded for albendazole (positive control). In both the 2.5 ml dose and distilled water (negative control) there were increases in tapeworm load following treatment (Table 1). All doses of garlic extract administered in the present study significantly ($p<0.05$) reduced strongyle in FEC. Goats treated with distilled water, however, had increase of about 26% in strongyle EPG of faeces (Table 1). Even though the efficacy of the 2.5 ml dose tended to be lower than all other doses, the differences were not statistically significant (Table 1). All doses of garlic extract and albendazole were also effective ($p<0.05$) against Eimeria spp. Garlic extract at 5 ml and 10 ml were similar ($p>0.05$) to albendazole in efficacy against GIT parasites irrespective of species. These were, however, higher ($p<0.05$) in efficacy against GIT parasites in general than 2.5 ml dose and distilled water.

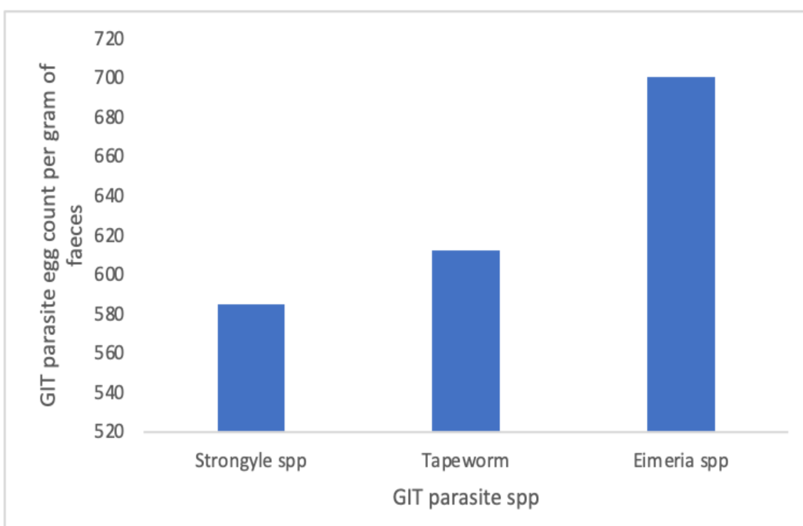

Fig 1: Egg count per gram (EPG) of faeces of various species GIT parasites in extensively raised goats under Guinea Savannah conditions

The effect of age on the efficacy of garlic extract at various doses in West African Dwarf goats is shown in Table 2. At all doses, age had no significant influence (p>0.05) on tapeworm and strongyle FEC. Similarly, FEC for *Eimeria spp.* in all age groups at all doses were similar except at 5 ml dose. Garlic extract at 5 ml dose had higher (p<0.05) efficacy against *Emeria spp.* in adults (100%) than younger (70%) individuals. Similarly, the 5 ml dose was more effective (p<0.05) against overall GIT parasites counts in older (100%) than younger goats (67%). Faecal egg count for GIT parasites studied were similar (p>0.05) for adult and young goats at 10 ml and 2.5 ml doses of the extract. Similarly, EPG of faeces were similar (p>0.05) for overall GIT parasites counts in adult and younger goats following treatment with albendazole and distilled water.

Sex of the host had no influence (p>0.05) on tapeworm*, Eimeria spp.* and strongyle EPG of faeces at all doses of garlic extract, and following both albendazole and distilled water treatment. Similarly, overall GIT parasites load was not influenced by host sex at all doses of garlic extract. Higher reduction (p<0.05) in overall GIT parasite FEC, however, was found in females (100%) than males (69%) following treatment with albendazole.

DISCUSSION

The overall pre-treatment prevalent rate of GIT parasites of 84% found in the present study is high, and comparable to the 89.3% (Hassan *et al*., 2019), 86.1% (Singh *et al*., 2015) and 94.5% (Jena *et al.,* 2018) reported in goats found in Giza Governorate (Egypt), Ranchi Jharkhand (India) and Madhya Pradesh (India), respectively. These were, however, higher than the 35.3% (Negasi *et al.,* 2012) and 28.7% (Das *et al*., 2017) found in goats in Mekelle town (northern Ethiopia) and Meghalaya (Hilly region of Ethiopia), respectively. The implication of these results is that GIT parasites are worldwide problems affecting goat production.

Consistent with the results of the present study, garlic powder was reported to significantly decrease FEC of GIT parasites (Ankri *et al.,* 1997; Waag *et al.,* 2010; Zhong *et al.,* 2019). Zhong *et al.* (2019) further noted that this impact was strengthened by the prolongation of the feeding time, and suggested that the decrease in FEC might be due to decreased fecundity of GIT parasites due to garlic powder supplementation (Strickland *et al.,* 2009). The reduction might also be due to the bioactive compounds in garlic, that might kill adult worms in both direct and indirect manner (Hoste *et al*., 2006). Using natural garlic extract in worm control, producers could achieve the same rates of production as using commercially available anthelmintic (Curry and Whitaker, 2010). This assertion is supported by the fact that garlic extract at 10 ml dose in the present study reduced overall GIT parasite load by 94% compared to albendazole (78%), though these were not statistically different.

Ijaz *et al.* (2009) reported efficacies of 8%, 16% and 21% at days 3, 7 and 14, respectively, in diarrheic sheep treated with garlic powder at 5

Table 1: Effect of dose on efficacy of garlic extract in fighting species of GIT parasite in West African Dwarf goats

Efficacies (Median (interquartile range) of garlic extract at various doses

Species of GIT parasite	**Doses (ml)** 2.5 (%)	5 (%)	10 (%)	Albendazole (%)	Distilled water %)	p-value
Tapeworm	25↑ (25↑-0)[b]	100 (88.9-100)[a]	92.9 (89.2-96.4)[a]	100 (100-100)[a]	11.1 (19.4↑-30.6)[b]	0.010
Strongyles *spp.*	66.7 (13.6-100)[ab]	100 (72.7-100)[a]	100 (76.2-100)[a]	83.3 (78.9-100)[a]	25.8↑ (33.3↑-2.3)[b]	0.008
Eimeria spp.	36.1 (33.3↑-62.5)[a]	100 (79.6-100)[a]	75 (69.3-79.6)[a]	87.5 (77.8-100)[a]	0 (25↑-10.7)[b]	0.020
Overall	14.3 (11.1↑-26.3)[b]	73.9 (67.9-94.4)[a]	94.4 (73.5-100)[a]	77.7 (71.4-100)[a]	25↑ (30↑-16.3↑)[b]	<0.001

Medians (interquartile range) within a row having no superscript in common are significantly different.
'↑' this is a negative figure implying an increase in GIT parasite load instead of a decrease

Table 2: Effect of age on the efficacy of garlic extract in West African Dwarf goats

Dosage (ml)	Tapeworm Young (%)	Tapeworm Adult (%)	p-value	*Eimeria spp.* Young (%)	*Eimeria spp.* Adult (%)	p-value	Strongyles *spp.* Young (%)	Strongyles *spp.* Adult (%)	p-value	Overall Young	Overall Adult	p-value
	Efficacies (Median (interquartile range) of garlic extract at various doses											
2.5	0 (12.5↑-25)	112.5 ↑ (156↑-69↑)	0.139	61.1 (41.7-80.6)	75↑ (138↑-13↑)	0.439	100 (50-100)	47 (29↑-75)	0.463	20↑ (64.4↑-28)	8.3 (11↑-14.3)	0.712
5	88.9 (83.3-94.4)	100 (100-100)	0.317	69.7 (68-71)	100 (100-100)	0.028	86.4 (79.5-93.2)	100 (50-100)	1.00	66.7 (46.7-71)	100 (78-100)	0.008
10	92.9 (89.3-96.4)	95 (92.5-97.5)	0.317	73.9 (68.8-79.1)	78.7 (76.9-80.6)	1.00	100 (77.8-100)	100 (84.6-100)	0.864	92.9 (80.5-100)	75 (71.4-77.8	0.455
Albendazole	100 (100-100	100 (100-100)	1.00	87.5 (71-93.8)	88.9 (83.3-94.4)	0.762	90 (79.4-100)	83.3 (75-91.7)	0.714	89.5 (82.1-100)	100 (70.6-100)	0.911
Distilled water	11.1↑ (19↑-31)	13 (23.5↑-21.5)	0.827	21.4 (10.7-32.1)	50↑ (75↑-25↑)	0.221	33.3↑ (46↑-23↑)	18 (0.25-37.1)	0.159	22.5 ↑ (31↑-14↑)	30↑ (65↑-28↑)	0.302
Overall	50 (5.6-92.9)	100 (6.3-100)	0.498	66.7 (48.7-85.9)	77.8 (25-100)	0.640	83.3 (78.9-100)	69.2 (41.4-100)	0.721	55.8 (7.6-83)	75 (62.5-100)	0.111

'↑' this is a negative figure implying an increase in GIT parasite load instead of a decrease

Table 3: Effect of sex on the efficacy of garlic extract in West African Dwarf goats

Dosage (ml)	Tapeworm Male (%)	Tapeworm Female (%)	P-value	*Eimeria spp.* Male (%)	*Eimeria spp.* Female (%)	P-value	Strongyles *spp.* Male (%)	Strongyles *spp.* Female (%)	P-value	Overall Male	Overall Female	P-value
	Efficacies (Median (interquartile range) of garlic extract at various doses											
2.5	0 (100↑-25)	25↑ (25↑-25↑)	0.554	36.1↑ (40↑-43.1)	50↑ (125↑-25)	1.00	13.6 (50↑-37.1)	15.1 (60↑-20)	0.480	8.3 (50↑-14.3)	29.8 (17-46)	0.085
5	92.5 (88.8-96)	100 (88.9-100)	0.564	100 (86.4-100)	100 (83.3-100)	0.796	100 (86.4-100)	80 (25-90)	0.519	69.1 (51.7-93)	76.4 (74.4-83)	0.281
10	100 (100-100)	92.9 (89.3-96)	0.317	87.5 (81-93.8	73.9 (68.8-79.1)	1.00	100 (83.3-100)	84.6 (76.9-92.3)	0.460	89.5 (74.4-100)	100 (85-100)	.543
Albend-azole	100 (100-100)	100 (100-100)	1.00	88.9 (83.3-94.4)	87.5 (71-93.8)	0.767	78.9 (75-80.8)	100 (100-100)	0.280	69.2 (67.1-72)	100 (78-100)	0.047
Distilled water	0 (25↑-25)	1.9↑ (8.5↑-4.6)	1.00	50↑ (75↑-50↑)	21.4↑ (10.7-32.1)	0.221	25.8↑ (45.8↑-11↑)	11.1↑ (11↑-33)	0.481	19.6↑ (28↑ -5↑)	25↑ (113↑- 22↑)	0.480
Overall	50 (0-100)	81.8 (2-100)	0.842	73.9 (29.2-94.4)	75.4 (51.6-100)	0.763	72.7 (9.1-100)	100 (65.8-100)	0.110	65.8 (14.3-85)	75 (29.8-100)	0.242

'↑' this is a negative figure implying an increase in GIT parasite load instead of a decrease

gm /animal. These are lower than efficacies found at all doses in all age groups at 14 days. The 5 ml and 10 ml doses for instance produced efficacy levels of 74% and 94%, respectively. Massamha *et al.* (2010) reported effective control of *Trichostrogyles* and strongyles using garlic extract. Similarly, strongyle *spp*. was effectively controlled using garlic extract at 5 ml and 10 ml doses in the present study. Contrary to these observations, Sutton and Haik (1999) observed that garlic is totally ineffective in reducing the egg count of strongyles in donkeys. A possible reason for this observation is that the authors boiled the garlic, as practiced by local farmers before using them for treatment. This practice is likely to render the garlic ineffective, as Allicin, an active ingredient in most plants with a medicinal value is unstable and is destroyed by the boiling process (Dausch *et al.,* 1990), also, all the important enzymes present in garlic are inactivated by heat (The Garlic Farm, 2022). Allicin exert anti-parasitic activity due to their special chemical structures, and can interact with sulfhydryl groups of proteins to block the physiological metabolism of parasites (Amagase *et al*., 2001; Coppi *et al*., 2006). These differences may also reflect host specificity in the efficacy of garlic extract against strongyles *spp*.

Similar to the results of the present study, Worku *et al.* (2009) noted significant reduction in boer goats FEC for coccidia at 10 ml dose, but not for *Haemonchus contortus*. In the present study, however, garlic extract effectively reduced coccidial FEC at all doses, even though the reduction at 2.5 ml tended to be minimal, the differences were not statistically significant. These results are consistent with the findings of Toulah and Al-Rawi (2007) in rabbits. The decrease in FEC of coccidia in goats drenched with garlic extract may be due to the allicin in garlic exerting its antioxidant and antiparasitic activity, thereby stimulating immunity by enhancing antibody response which directly kills the sporozoites (Khan *et al.,* 2012; Kim *et al.,* 2013). The reduced FEC may also be due to the presence of phenolic compounds in garlic acting on the cytoplasmic membrane of *Eimeria*, making changes in their cation permeability, and leading to their death (Tanweer *et al.,* 2014). The higher reduction noticed in adults compared to young goats is significant, as the older individuals have better immunity than the younger individuals (Metzger, 2017). Natural remedy such as garlic act at different levels and multiple links of the immune system, and can act simultaneously on multiple targets to correct the low immune status of the body (Wang *et al.,* 2020), and at the same time, enhance the patient's resistance (Wang *et al.,* 2020). It is, therefore, not surprising that the 5 ml dose was more effective at reducing overall GIT parasite load in adults than kids, as this may have corrected the low immunity in the kids (67% efficacy), and enhanced the higher immunity in the adult goats (100% efficacy). It is also possible that a higher dose than 5 ml may be required to sufficiently reduce GIT parasite load in kids, as evidenced by the 10 ml dose used in the present study. This reduced overall GIT parasites equally in both young and adult goats. Coccidiosis is one of the most important diseases of kids and is responsible for diarrhoea, weight loss and even death (Dai *et al*., 2006). All goats probably are infected with *Coccidia* at some stages of their life, but only a small percentage of them actually become ill (Dai *et al.,* 2006). It is important to define the spectrum of activity of garlic in light of the reported diversity of *Coccidia* species infecting goats (Norton, 1986).

Consistent with the observations of the present study, Zafar *et al*. (2001) reported that *A. sativum* and *C. Mexicana* extracts were equally effective against worms, including tapeworms in vitro. *A. sativum* was 100% effective in 6 h, while *C. Mexicana* attained 83.4% effectiveness within the same period. In the present study, garlic extract successfully reduced tapeworm FEC by 100% and 93%, respectively, for the 5 ml and 10 ml doses.

Ijaz *et al*. (2009) reported that garlic at higher dose could be successful in reducing the number of oocytes burdens. Rahman and Seip (2006) suggested a dosage of 5 ml of *A*. *sativum* juice per animal per day, while another study (Zhong *et al*., 2019) suggested 50 g garlic powder/kg of the feed for 84 days. These methods, however, are not necessarily the most practical due to low palatability of garlic (Militz *et al.,* 2013). In the present study, *A*. *sativum* was administered as a drench in the form of suspension, and aqueous

A. sativum extract is reported to exert its antibiotic properties even at a dilution rate of 1:1000 (Massamha *et al.,* 2010). Similarly, efficacy increased with increasing inclusion levels of the herb, if they were fed directly. There is, however, the need to isolate the active compound in *A. sativum* and determine the drug response curves of the parasite in question.

Curry and Whitaker (2010) reported that there was no significant difference in body weight, FEC and PCV in sheep and goat when garlic extract (garlic barrier) was administered compared to commercial anthelmintics. According to Sutton and Haik (1999), many people in Israel consider garlic as a viable alternative to commercial anthelmintics. Little scientific research has been conducted on using garlic as an anthelmintic in goat, but it is thought that garlic does not prevent the production of parasite eggs, but rather the hatching of eggs into larvae (Bastidas, 1969). This reduction in larvae on herbage will subsequently reduce the buildup of nematode burdens in hosts. In the current study, however, *A. sativum* appears to have direct antihelmentic effect on resident worms in the animals. The results indicate that there was a substantial die off, which allowed infectivity differential to be observed in the EPG percent reductions.

CONCLUSION

The overall prevalence of GIT parasites in Djallonke goats under Guinea savannah conditions is high. Garlic extract as an oral anthelmintic in goats is a viable option to commercially available chemicals. Garlic extract at 5 ml and 10 ml doses were effective in reducing the FEC of strongyles, tapeworms and *Eimeria spp*. Higher doses of garlic extract than 5 ml are required for effective GIT parasites reduction in younger goats. Both sexes of goats responded to all doses of garlic extract equally. Except the 5 ml dose, all doses of garlic extract acted equally on both young and adult goats. A better understanding of the specific mechanism of action of garlic in the animal and the immune system could lead to future solutions to controlling anthelmintic resistant parasites in small ruminants.

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