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Original article

In vivo lavicidal effects of ginger (*Zingiber officinale*) powder on pigs artificially infected with gastointestinal nematode larvae

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ABSTRACT

Anthelminthic resistance due to the mismanagement of conventional drugs remains a major constraint in eradicating gastrointestinal parasites, hence the need for alternatives drugs which are more ecofriendly and affordable. This paper evaluated the *In vivo* lavicidal effect of ginger *Zingiber officinale* in pigs experimentally infected with association of *Strongyloides ransomi, Hyostrongylus rubidus, Trichostrongylus colubriformis* and *Globocephalus urosubulatus* L3 larvae. The experiment, conducted at the teaching and research farm of the University of Dschang consisted of 12 pigs divided into two treatment groups (the control group, T0 and the treated group, T1). The control group (T0) was infected with 2650L_3 larvae and was not treated. The treated group (T1) was infected with 2650L_3 larvae and treated with 500g of ginger powder. Six weeks after infection, faecal samples were collected directly from the rectum of all the pigs to determine the presence of eggs, the faecal egg count, and also to carry out larval culture. Ginger powder reduced the shedding of eggs in *Strongyloides ransomi* and strongylid parasites by 12.9% and 53.4% respectively. The mean log10 EPG in the untreated group was also significantly higher than that in the treated group. The L_3 larvae obtained after larval culture were of the same species as those used to infect the pigs. The larvae cultures showed that ginger reduced the shedding of eggs in *Strongyloides ransomi, Hyostrongylus rubidus, Trichostrongylus colubriformis* and *Globocephalus urosubulatus* by 32.97%, 18.84%,

9.46%, and 17.41% respectively. The mean L3 nematode larvae cultured in the treated group was significantly lower ($p<0.05$) than in the untreated group for *Strongyloides ransomi* and *Trichostrongylus colubriformis.* In conclusion, ginger powder reduced the shedding of eggs of all the studied nematode species, and the eggs shed were viable. In order to definitely conclude on the effect of ginger powder on these nematodes in pigs, further studies on the duration of treatment and the active compound in ginger powder are required.

1. Introduction

The World's population is constantly increasing thus leading to an increase in protein demand. Because of this high demand the livestock sector is growing more dynamically than any other agricultural sector with the growth in meat consumption in the developing world being greater than that of the developed countries (Kagira et al., 2003). Domesticated pigs raised for meat are among the main sources of protein in Cameroon. The local demand for pork is high and most of the pork produced is consumed locally (Mutua et al., 2010). A part from African swine fever and erysipelas, parasitism in domestic pigs has been reported to be the most common and important disease in tropical and subtropical countries (Permin et al., 1999; Nganga et al., 2008). Gastrointestinal parasites are responsible for the substantial losses in the productivity of swine and other livestock industry (Boes et al., 2000; Joachim et al., 2001) since the infections result in reduced weight gains, decreased litter sizes, poor growth rates, visceral organ condemnation at slaughter and deaths (Stewart and Hoyt, 2006).

The control of these infections is therefore necessary. Over the years most parasite control measures have been based exclusively on the use of chemotherapeutic drugs such as: ivermectin, levamisole, albendazole, piperazine etc. However, the long existence and the improper handling or management of these drugs has led to several limitations. The first one is the rapid development of antihelmintic resistance of some parasitic strains to most antihelmintics especially those belonging to the strongyloidae family (Cheng et al., 2014; Brunet et al., 2008; Hoste et al., 2006) Secondly, there is an increased concern of consumers over drug residues in meat and milk products, and a potential risk for environmental contamination (Barrau et al., 2005). Also most of these antihelmintics are usually unaffordable and unavailable to most farmers especially in the remote areas. It is therefore necessary to seek alternative means against gastrointestinal parasites which are readily available, affordable and environmentally friendly. These include substances produced from plants, since plants have the advantage of sustainable supply and are ecologically friendly (Al-Shaibani et al., 2009; Bachaya et al., 2009; Deeba et al., 2009; Sindhu et al., 2010). Several surveys have reported the use of medicinal plants against the larval stage of gastrointestinal nematodes. However, most of them have only been tested *in-vitro* (Lin et al., 2010) and also on a single species of parasite (Moazeni and Nazer, 2011). Thus, there is a gap in knowledge regarding the *in vivo* efficiency of such plants against a wide range of gastrointestinal parasites.

One of the most commonly used plants which has been tested for its antihelmintic properties is the ginger rhizome (*Zingiber officinale*). The roots of this rhizome *Z. officinale* contains several active compounds, including gingerol, shogaols, gingerdiol, gingerdione and volatile oils, which are its medically active constituents. *In vitro* studies have proven that *Z. officinale* and its constituents exert lavicidal effects on some parasites. For instance, Lin et al. (2010) analysed the *in vitro* effect of isolated compounds (gingerols, shogaols and hexacurcumin) of *Z. officinale* rhizomes against *Angiostrongylus cantonensis* and *Anisakis simplex* larvae and concluded that these compounds exhibited larvicidal activity against the larvae of the above mentioned nematodes by directly killing or reducing spontaneous movement. It was revealed that gingerol showed higher larvicidal effect than mebendazole and albendazole and resulted in 100% lethality against the larvae of *Anisakis simplex*. Also Moazeni and Nazer (2011) analysed the effect of methanolic extract of *Z. officinale* rhizome on the larval stage of *Echinococcus granulosus*; the results revealed that the lavicidal activity of *Z. officinale* extract at a concentration of 25, 50 and 100 mg/mL killed the larvae after 60, 40 and 30 min of its application respectively. In the same light, Iqbal et al. (2006) analysed the effect of crude powder and aqueous extract of ginger in sheep naturally infected with mixed species of gastrointestinal nematodes, including *Trichostrongylus colubriformis*, *Haemonchus contortus*,

Oesophagostomum columbianum, *Trichostrongylus axei*, *Trichuris ovis* and *Strongyloides papillosus* and found out that the aqueous extract and ginger crude powder reduced the shedding of eggs by 25,6 % and 66.6% respectively. Despite all these confirmations, no study has been carried out *in vivo* to test the larvicidal effect of this plant on a wide range of nematodes species in infected pigs. Indeed, previous studies on pig parasitism in Cameroon showed that mixed infections with many helminth species was common than mono infections; Kouam et al. (2018) showed a higher prevalence of mixed infection (53%) than mono infection (47%) in Bamboutus, while Kiambom et al. (2017) in the north west region of Cameroon found that in pigs there existed no mono infection but rather double, triple, quadruple and multi infections with gastrointestinal parasites. Therefore, the main aim of this study was to evaluate the *in vivo* lavicidal effect of the rhizome powder of *Zingeber officinale* in pigs experimentally infected with an association of *Strongyloides ransomi, Hyostrongylus rubidus, Trichostrongylus colubriformis* and *Globocephalus urosubulatus.*

2. Materials and methods

2.1. Study area

The experiment was carried out at the teaching and research farm of the University of Dschang. Dschang is situated between the latitudes 05°22'58" and 05°30'40" N and longitudes 9°58'55" and 10°7'23" E. It has an average altitude of 1420m in the West region of Cameroon. This region experiences the rainy season from mid-march to mid-November and the dry season from mid-November to mid-march. Precipitations vary between 1500 and 2000 mm/year and the temperatures vary between 14 and 25°C. Dschang has an average relative humility of 76, 8% (Pamo et al., 2005).

2.2. Plant material

The plant material was made of the ginger rhizome (*Zingiber officinale)* harvested from the Santa sub division in the North West region of Cameroon. This plant is usually cultivated in the North West and western regions of Cameroon. The rhizomes of this plant were bought directly from a farmer and then were washed, cleaned and then air-dried under a shade for at least 2 weeks. The dry product was then blended with an electric blender to obtain crude powder.

2.3. Animal material

Animals used for this experiment were 12 cross breed pigs of two months and having an average weight of 20kg. These pigs were purchased from a single local farm. They were hosted in a raised floor piggery built with hard wood. The piggery had four different compartments for the different treatments of 6m² (2m×3m) each corresponding to the different treatments. Plank feeders with a 50 litres capacity were constructed and placed in each compartment. Well-designed tire rings of 30 litres capacity were placed in each compartment to serve as water through.

In addition to the proper hygiene and sanitation that was carried out before and during the experiment, vaccination against erysipelas was provided by officials of the Ministry of livestock and fisheries (MINEPIA) in Dschang. Also antibiotics such as combikel and penstrip as well as multivitamins such as stress-vita were given to prevent interference by other diseases.

2.4. Culture of nematode parasitic larvae

Before the experiment proper was conducted, a pre-survey was carried out, whereby pig farms in the Dschang locality were visited and fresh faeces was collected and analysed using the simple flotation technique in order to identify and quantify the most prevalent association of parasites which were *Strongyloides ransomi* and Strongyle parasites. Then a faecal culture was performed to obtain infective larval stages as described by Soulsby (1982) and MAFF (1986).

This culture was done by briefly placing 5 grams of positive samples of faeces in Petri dishes in layers of 2mm depth. The dishes had loose covers that did not prevent air circulation but deterred flies and reduced desiccation. There were two different batches of the same sample. The first batch was incubated at a temperature of about 27°C for 48 hrs to collect *Strongyloides ransomi* and *Trichostrongylus colubriformis* nematodes and the second batch was incubated for 11 days more to obtain *Hyostrongylus rubidus* and *Globocephalus urosubulatus.*

After incubation, the larvae were collected using the Baermann technique and identified under the microscope with the help of keys (MAFF, 1986). The different L3 larvae were identified to determine the composition of the species involved in the mixed infection which were *Strongyloides ransomi, Hyostrongylus rubidus, Trichostrongylus colubriformis* and *Globocephalus urosubulatus.*

2.5. Experimental design

This experiment consisted of 12 pigs of equal age (2 months) and approximately same weight (20kg). Before the experiment, they were treated against gastrointestinal parasitism using Mebendazole 5mg/kg. The pigs were randomly divided into two comparable groups of 6 pigs each (3 males, 3 females) and housed per groups of treatment. Males and females of each treatment were housed separately. The pigs were fed with commercially compounded dry feed and given tap water to drink *ad libitum*. The feed was given to the pigs at equal quantities (3kgs per pen) and intervals (7am and 6pm). The pigs were given an adaptation period of one week before inducing the various treatments.

The untreated group (T0) was infected with 2650L_3 larvae and was not treated. The treated group (T1) was infected with 2650L_3 larvae and treated with 500g of ginger powder. The pigs were inoculated orally using a pipette. Inoculation was done twice. 1400L3 larvae per 5mls was collected with *Strongyloides ransomi* constituting 60% and *Trichostrongylus colubriformis* constituting 40% and inoculated on the third day after incubation to the pigs. Then the second batch of 1250L3 was collected per 5mls with *Hyostrongylus rubidus* constituting 55% and *Globocephalus urosubulatus* constituting 45% and inoculated 11 days after the first inoculation. Therefore, a total of (2650 L3) mixed infective larvae was inoculated orally to pigs using a pipette.

The ginger powder was administered once and immediately by mixing it in pig feed after the second round of inoculation. Four weeks after the second inoculation, faecal samples were collected directly from the rectum of all the pigs to determine the presence of eggs and the faecal egg count. Given that the eggs of the strongyle group have similar features thus making it difficult to differentiate using the microscope, a faecal culture was conducted to differentiate the eggs of the strongyle groups and to confirm whether the same eggs which were inoculated were the same eggs that were shed. The four different larvae expected were differentiated and confirmed (Fig. 1) using keys of Soulsby (1982) and MAFF (1986).

After culture, 2ml of the collected solution containing larvae were used to quantify the larvae number by separately counting the different larvae using the Mc master slide under a microscope.

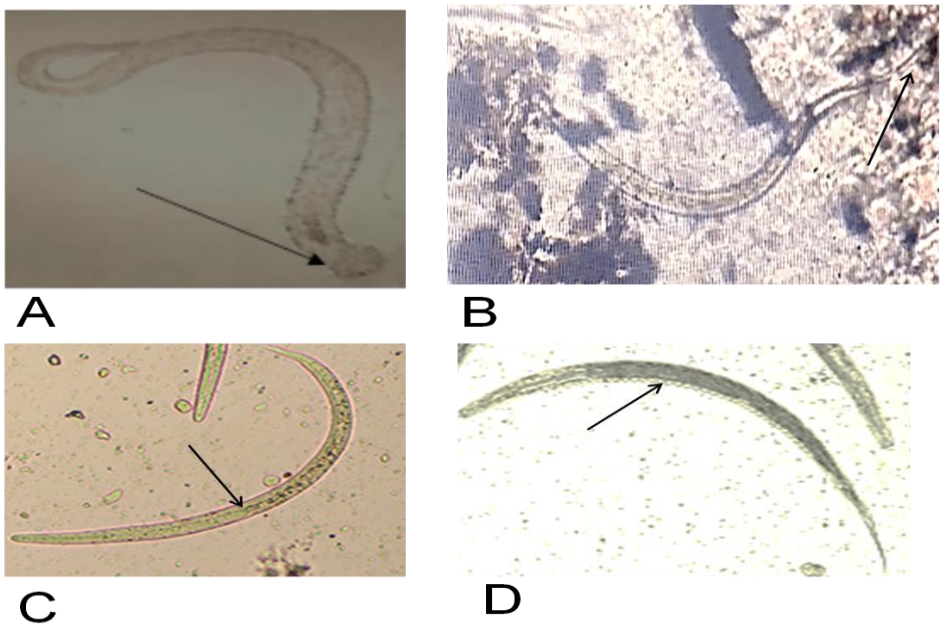

Fig. 1. Pig parasites larvae cultured: *Globocephalus urosubulatus* larva with a flat anterior (see arrow) (A); *Hyostrongylus rubidus* larva with a very long posterior (see arrow) (B); *Strongyloides ransomi* (see junction between oesophagus and intestine) (C); *Trichostrongylus colubriformis* larva with a zigzag edge along the body length (see arrow) (D).

2.6. Determination of egg presence and load

The quantitative analysis was performed using the McMaster floatation technique with Sodium chloride as the floatation solution (MAFF, 1986).

2.7. Statistical analysis

The data collected was entered into Microsoft Excel and exported to SPSS version 20.0 for statistical analysis. All data obtained were submitted to logarithmic transformation before the statistical analysis. Then the T-test independent sample was performed to compare the treated and untreated groups on one hand and then to compare males and females on the other hand. Results were expressed as mean±standard deviation. The limit of significance was 5%.

3. Results and discussion

3.1. The effect of ginger treatment on the shedding of eggs

The absolute and relative reduction of nematode egg production is presented in Table 1. Ginger reduced the shedding of eggs in both *Strongyloides ransomi* and Strongyle groups by 12.9% and 53.4% respectively. Table 2 shows the difference in the mean $\log_{10}$ of nematodes between the treated and untreated groups.

There was no significant difference in the shedding of eggs between sex both of the same group and between the two groups for *Strongyloides ransomi*, and between sex of the same group for Strongyle. There was also no significant difference between the total means of both groups. The shedding of strongyle eggs in pigs were significantly higher ($p<0.05$) in males and females of the untreated group when compared to their peers in the treated group (Table 2). The mean log10 EPG in the untreated group was also significantly higher than that in the treated group.

Table 1
Absolute and relative reduction of nematodes eggs in pigs after ginger treatment.

	Mean ± SD							
	Untreated		Treated		Total eggs shed		Absolute reduction	% reduction in egg production
Nematodes	Male	Female	Male	Female	Untreated	Treated		
Strongyloides ransomi	2175±327.87	2350±225	1525±548.29	2416±685.72	13575	11825	1750	12.9%
Strongyle eggs	5866.67±875.48	6658.33±469.26	2983.33±94.65	2850±433.73	37575	17500	20075	53.4%
Total	4020.84±601.68	4504.17±347.13	2254.17±321.5	2633±559.71	51150	29325	21825	42.67%

SD: Standard deviation; % = percentage.

Table 2
Mean $\log_{10}$ EPG of nematodes between treated and untreated pigs according to pig gender.

		Test groups of pigs		
Nematode species	Pig sex	Untreated group (n = 6)	Treated group (n = 6)	p- value
Strongyloides ransomi	Females (n = 3)	3.37±0.04	3.37±0.14	0.999
	Males (n = 3)	3.33±0.7	3.16±0.15	0.156
	Mean (n = 6)	3.35±0.05	3.27±0.17	0.277
	p-value	0.478	0.161	
Strongyle eggs	Females (n = 3)	$3.82±0.03^{a}$	$3.45±0.06^{b}$	0.001
	Males (n = 3)	$3.76±0.07^{a}$	$3.47±0.01^{b}$	0.002
	Mean (n = 6)	$3.79±0.06^{a}$	$3.46±0.04^{b}$	0.000
	p-value	0.242	0.576	

n: number of samples; (a, b,): on the same line, values affected with different letters differ significantly ($p<0.05$).

3.2. The effect of Ginger treatment on the culture of larvae

The effect of ginger powder on the culture of larvae is presented in Table 3.

The L_3 larvae obtained after larval culture were of the same species as those used to infect the pigs. All the egg types shed were viable. The percent reduction in *Strongyloides ransomi, Trichostrongylus colubriformis, Hyostrongylus rubidus,* and *Globocephalus urosubulatus* was 32.97%, 18.84%, 9.46%, and 17.41% respectively (Table 3).

Table 4 shows the difference in the mean $\log_{10}$ of the different nematode larvae between the treated and untreated pigs. The mean L3 nematode larvae cultured in the treated pigs was significantly lower ($p<0.05$) than in the untreated pigs for *Strongyloides ransomi* and *Trichostrongylus colubriformis*. In relation to pig sex, the mean L3 larvae cultured in female pigs was significantly lower ($p<0.05$) in treated pigs than in untreated pigs for *Strongyloides ransomi, Trichostrongylus colubriformis* and *Globocephalus urosubulatus.* Within a group, the mean *Globocephalus urosubulatus* L_3 larvae was significantly higher ($p<0.05$) in females than males in the untreated pigs but the reverse was observed in the treated group of pigs.

Table 3
Absolute and relative reduction of nematodes larvae after ginger treatment of pigs.

Nematode larvae	Number of larvae in untreated pigs	Number of larvae in treated pigs	Absolute reduction	% reduction
Strongyloides ransomi	461	309	152	32.97
Trichostrongylus colubriformis	207	168	39	18.84
Hyostrongylus rubidus	296	268	28	9.46
Globocephalus urosubulatus	270	223	47	17.41
Total	1234	968	266	21.56

Table 4
Mean $\log_{10}$ of the number of L3 nematode cultured larvae between treated and untreated pigs according to pig gender.

Nematode species	Pig sex	Test groups		p-value
		Untreated group (n = 6)	Treated group (n = 6)	
Strongyloides ransomi	Females (n = 3)	1.87±0.05a	1.65±0.08b	0.016
	Males (n = 3)	1.89±0.03	1.76±0.09	0.059
	Mean (n = 6)	1.88±0.04a	1.70±0.09b	0.001
	p-value	0.618	0.204	
Trichostrongylus colubriformis	Females (n = 3)	1.54±0.04a	1.40±0.07b	0.033
	Males (n = 3)	1.53±0.07	1.49±0.04	0.405
	Mean (n = 6)	1.54±0.05a	1.44±0.07b	0.023
	p-value	0.757	0.127	
Hyostrongylus rubidus	Females (n = 3)	1.69±0.06	1.62±0.13	0.460
	Males (n = 3)	1.68±0.10	1.66±0.07	0.716
	Mean (n = 6)	1.69±0.07	1.64±0.09	0.357
	p-value	0.949	0.695	0.191
Globocephalus urosubulatus	Females (n = 3)	1.73±0.05aA	1.47±0.06Bb	0.005
	Males (n = 3)	1.55±0.08B	1.64±0.06A	0.203
	Mean (n = 6)	1.64±0.11	1.56±0.10	0.226
	p-value	0.030	0.032	0.470

n: number of samples; (a, b,): on the same row, values affected with the different letters differ significantly ($p<0.05$); (A, B,): on the same column, values affected with different letters differ significantly ($p<0.05$).

The idea of this study was to see whether ginger powder treatment could stop infestation. i.e. to check if the administration of ginger powder could actually prevent the development of the adult stages of the parasites. The results showed that there was still the shedding of eggs in the treated and untreated groups though there was a reduction in egg shed by 42.67% when the treated and untreated groups were compared. The reason why ginger did not completely prevent the shedding of eggs could be attributed to the dose of ginger powder administered.

Many studies (Moazeni and Nazer, 2011; Iqbal et al., 2006; El-Sayed and Safar, 2014) have proven that the effectiveness of ginger treatment increases in a dose dependent manner, i.e. the higher the dose, the more effective the treatment. In this study a dose of 500g of ginger was administered once which was the highest dose the pig could eat at once. Given that each pig could only eat at most 500g of ginger incorporated in their food, we suggest that this dose be repeated for several days. Also another reason why ginger could not completely prevent infestation could be attributed to the time of administration of ginger powder and the duration of treatment. In the case of this study, the ginger powder was administered 11 days after the first inoculation and 24 hrs after the second inoculation of L3 larvae. This delay in the administration of ginger treatment could have given the L3 larvae enough time to penetrate the intestinal walls and migrate to the lungs to continue their cycle especially *Strongyloides ransomi* and *Trichostrongylus colubriformis* which was first inoculated. When this happens the ginger treatment ingested is not more in direct contact with the L3 thus reducing the potency of action of the treatment. Also still in this light of the time of treatment, *In vitro* studies (Lin et al., 2010; Moazeni and Nazer, 2011; Iqbal et al., 2006; El-Sayed and Safar, 2014) showed that after the culture and collection of L3 larvae of various parasites, they were immediately placed in vials already containing ginger treatment which led to the direct paralysis and the death after a few hours. This shows that the efficiency of ginger powder treatment could possibly increase if the treatment is administered at the same time or before the inoculation of L3 larvae. However, more research is required to test the effect of time of treatment administration on the development of adult stages of parasites.

The results showed that there was a reduction in egg shed in both *Strongyloides ransomi* and strongylid parasites groups by 12.9% and 53.4% respectively. The reduction in the shedding of eggs in the treated group compared to the untreated group was significant ($P \leq 0.05$) for the strongyle species. The significant reduction in egg shed of the strongyle group shows that ginger powder treatment was efficient to a certain extent in preventing infestation of this nematode group. The mechanism of action of *Zingeber officinale* has not yet been well explained but there are speculations that the mechanism of action of ginger may be both central and peripheral i.e. anticholinergic and antihistaminic (Qian and Liu, 1992). Nematode larva muscles have neuromuscular junctions with acetylcholine as the neurotransmitter (Neal, 2002). Recently it has been reported that ginger exhibits gastrointestinal prokinetic activity via activation of cholinergic receptors (Ghayur and Gilani, 2005). Therefore, the cholinergic components of the ginger crude powder which are mainly gingerols, gingerdiones, shogoals and hexacucurmins probably activated the cholinergic receptors found on the neuromuscular junctions causing a spastic paralysis that led to the expulsion of some strongyle larvae that came in contact with the powder. Given that no such study has been carried out on the *in vivo* lavicidal effect of ginger, the results of this experiment could only be compared to those experimented *in vitro* and on different species. This study is similar to that of Iqbal et al. (2006) who analysed the effect of crude powder and aqueous extract of ginger in sheep naturally infected with mixed species of gastrointestinal nematodes, including *Trichostrongylus colubriformis*, *Haemonchus contortus*, *Oesophagostomum columbianum*, *Trichostrongylus axei*, *Trichuris ovis* and *Strongyloides papillosus* and found out that the aqueous extract and ginger crude powder reduced the shedding of eggs by 25,6 % and 66.6% respectively. Also the reduction in egg shed due to ginger treatment confirms the results of Lin et al. (2010) who analysed the *in vitro* effect of *Z. officinale* compounds against *Angiostrongylus cantonensis* and *Anisakis simplex* larvae and concluded that these compounds which included gingerols, gingerdiones, zingiberines and shogaols exhibited larvicidal activity against the larvae of the above mentioned nematodes by direct killing or reducing spontaneous movement. It was revealed that gingerol showed higher larvicidal effect than mebendazole and albendazole and resulted in to 100% lethality against the larvae of Anisakis simplex. Also the significant lavicidal effect of ginger treatment on eggs of the strongyle group are in conformity with that of Moazeni and Nazer (2011), who proofed the effectiveness of methanolic extract of *Z. officinale* on the larval stage of *Echinococcus granulosus*. These authors showed that *Z. officinale* extract at a concentration of 25, 50 and 100 mg/mL killed the larvae after 60, 40 and 30 min of its application respectively.

Ginger crude powder was chosen for this research because ginger crude powder was shown to be more efficient in reducing egg shed than aqueous extract. In fact, according to Iqbal et al. (2006) who analysed the effect of crude powder and aqueous extract of ginger in sheep naturally infected with mixed species of gastrointestinal nematodes (*Trichostrongylus colubriformis*, *Haemonchus contortus*, *Oesophagostomum columbianum*, *Trichostrongylus axei*, *Trichuris ovis* and *Strongyloides papillosus*), the ginger aqueous extract and ginger crude powder reduce the shedding of eggs by 25.6% and 66.6% respectively. Also Hayajneh et al. (2019) evaluated the resistance of various antihelmintics in comparison to ginger powder and showed that parasites had a lower

resistance to ginger powder as compared to albendazole and ivermectin which showed higher antihelmintic resistance. Moreover, ginger crude powder can easily be prepared than extracts by most farmers.

Due to the significant effect exhibited by ginger crude powder in the shedding of strongyle eggs, a culture was necessary to differentiate these eggs to ensure that the same species that were inoculated were the same species that shed eggs and to evaluate which strongyle species was actually the most affected. The larvae culture results of both treatments confirmed that the species that were inoculated were exactly the species that shed eggs. Also all the eggs shed were viable as reflected by the successful culture of *Strongyloides ransomi* and strongyle species. This means that ginger powder treatment did not prevent the shed eggs from hatching. The percentage reduction in *Strongyloides ransomi, Trichostrongylus axei, Hyostrongylus rubidus,* and *Globocephalus urosubulatus* were 32.97%, 18.84%, 9.46%, and 17.41% respectively. This shows that the ginger powder treatment acted more on *Strongyloides ransomi* and acted least on *Hyostrongylus rubidus.* The ginger treatment significantly reduced ($p \leq 0.05$) the culture of larvae of *Strongyloides ransomi* and *Trichostrongylus colubriformis.* According to Roepstorff and Nansen (1998), the adult females of *Strongyloides ransomi* and *Globulecephalus sexalatus* have higher fecundities as compared to the adult females of *Trichostrongylus* sp and *Hyostrongylus rubidus* which rather have lower fecundities. This could explain why much more eggs were shed by *Strongyloides ransomi* and *Globocephalus urosubulatus* as reflected in the culture compared to the latter.

In relation to pig sex, the mean L3 larvae cultured in female pigs were significantly lower ($p<0.05$) in treated pigs than in untreated pigs for *Strongyloides ransomi, Trichostrongylus axei* and *Globocephalus urosubulatus*. Within a group, the mean *Globocephalus urosubulatus* L_3 larvae was significantly lower ($p<0.05$) in females than males in the treated group of pigs. This implies that despite the administration of ginger treatment, male pigs generally shed more eggs than female pigs. This increase in the shedding of eggs by male pigs can be attributed to the interventions of some male hormones such as androgens which renders them more susceptible to infections than females. In fact, according to Barger (1993), female sheep are more resistant than males against gastrointestinal parasites attributed to the fact that the estrogens produced by females have a stimulatory effect on the immune response against GIT nematodes while androgen produced by males suppressed the immune response (Seli and Arici, 2002). Though this finding was on sheep, similar explanation can be attributed to pigs since sheep and pigs are both mammals.

In conclusion, ginger powder reduced the shedding of eggs of all the studied nematode species, and the egg shed were viable. In order to definitely conclude on the effect of ginger powder on theses nematodes in pigs furthers studies on the duration of treatment and the active compound in ginger powder are required.

Conflicts of interest

The authors declare that they have no conflicts of interest.

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