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Effect of *Allium sativum* extract on growth performance, nutrient intake, digestibility, and nitrogen utilization of West African Dwarf goats artificially infected with *Haemonchus contortus*

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ABSTRACT: This study was conducted to investigate the effect of *Allium sativum* on the performance of West African Dwarf (WAD) goats artificially infected with Barber's pole worm (*Haemonchus contortus*). Twenty-five WAD goats were randomly assigned to five treatment groups in a Completely Randomised Design in a 56-day performance trial, after which the animals were moved to a metabolic cage for a digestibility study with an adjustable period of 7days, after which the digestibility study was carried out for five days. The treatments included a negative control (saline water 7 ml), a positive control (10 mg/ml of albendazole), and three groups received garlic (*A. sativum*) extract at varying concentrations (7.5, 12.5, and 17.5 mg/ml). The results showed that final weight, weight gain, daily weight gain, dry matter intake, and feed conversion ratio were significantly ($p<0.05$) influenced by the treatments. The highest values for final weight (10.64 kg), weight gain (2.10 kg), and daily weight gain (37.48 g/day) were recorded in the group treated with 10 mg/ml of albendazole, which could be related to the ability of the animals to better utilise nutrients obtained from feed consumed with minimal interference from the parasitic worm. However, the final weight was comparable to that of goats treated with *A. sativum* extract at different levels. The lowest final weight (8.77 kg) was observed in the negative control group. Nitrogen intake, faecal nitrogen, nitrogen balance, and nitrogen absorption also showed significant ($P < 0.05$) differences among treatments. The highest nitrogen intake (331.07 g/day) was recorded in the negative control group, which was comparable to the value observed in the albendazole-treated group (303.90 g/day). Meanwhile, lower but similar nitrogen intake values were obtained in the groups treated with different concentrations of *A. sativum* extract.

Keywords: *Allium sativum*, barber's pole worm, feed conversion ratio, nematodes, nitrogen utilisation, performance.

INTRODUCTION

Helminths are examples of endoparasitic worms within the group of nematodes. They are one of the major causes of death and reduced performance in goats and sheep farming systems, with an estimated number of thousands of deaths each year, particularly in tropical and subtropical regions (Arsenopoulos *et al.*, 2021). Unlike sheep and cattle, goats are more predisposed to gut worm infestation compared with other ruminants, which are more resilient. Under normal foraging situations, goats have been shown to be more severely infected than sheep, with much higher burdens and more damage to the gut, and this is due to their inability to stimulate an adequate immune response (Torres-Acosta and Hoste, 2008).

In animals, nematodes cause direct losses due to death and indirect losses due to reduced productivity through reduced feed intake and live-weight gains and a decrease in skins, wool, or mohair (Forbes *et al.*, 2000; Roeber *et al.*, 2013). They also render them more susceptible to other infections. The most important nematode parasites of ruminants causing production losses are predominantly those present in the gastrointestinal tract. These include species of *Haemonchus, Cooperia, Bunostomum, Gaigeria, Fasciola, Oesphagostormum, Trichuris, Trichostronglus, etc* (Fajimi *et al*., 2001). Among these species, *Haemonchus contortus* has been found to be the most abundant in nature (Ayankoso, 2022) all over the world inflicting diverse damages on ruminants. *H. contortus* possesses a morphological structure which is difficult for goats to cope with (Saddiqi *et al.*, 2011; Torres-Fajardo *et al*., 2020).

Dietary modification has been used to increase host resistance and/or resistance to parasite infestation (Ayankoso *et al*., 2012a; 2012b; Sonibare *et al*., 2016; Kearney *et al.,* 2016). More specifically, the maintenance of host resistance is more sensitive to protein supply (Cei *et al*., 2017) than to energy supply within a range of nutritional conditions which would be predicted for well-managed sheep and goats in practice (Ayankoso *et al*., 2012a). The performance of grazing animals can be poor due to lack of adequate dietary protein and energy coupled with challenges posed to them by worms (Walkden-Brown and Eady, 2003; Haile *et al.,* 2004; Ayankoso *et al*., 2012a; 2012b; Sonibare *et al.*, 2016; Kearney *et al.,* 2016).

Before the advent of chemosynthetic drugs, various nutraceutical plants have been used in the treatment of ailments in both human medicine and animal veterinary with great testimony of recovery (Singh *et al*., 2012). Up till today, herbs remain one of the most significant sources of medicines, and most of the modern drugs used in the present age are obtained from plant products (Singh *et al*., 2012). There are studies conducted on the impact of *A. sativum* on the performance of West African Dwarf goats (Ikyume *et al*., 2017; Chouhan *et al*., 2023), but there is limited or no study carried out on the impact of *Allium sativum* on the performance, nutrient intake, nutrient digestibility and nitrogen utilisation of West African Dwarf goats that are artificially infected with *H. contortus.* This study aims to provide valuable insights into the impact of *A. sativum* extract drench on growth performance, nutrient intake, nutrient digestibility, and nitrogen utilization of West African Dwarf goats artificially infected with *Haemonchus contortus. A. sativum* is considered for this study based on its abundance in protein, minerals, vitamins, energy and highly rich sulphur compounds such as allicin, allin, diallyl sulfide, diallyl disulfide, ajoene and others which have tendency to restrict the growth and proliferation of microbial organisms and parasitic worms which might be due to their antioxidant and antimicrobial properties (Kolapo *et al*., 2007; Shang *et al*., 2019). Garlic has been reported to be rich in tannins which could bound to the surface of the eggshell, perhaps through tannin−protein interfaces, which either disallowed the protein metabolism that cause the actual hatching process (Molan and Faraj, 2010) or the tannin form covering around the egg and inhibits the penetration of the larvae through the eggshell (Engstrom *et al*., 2016). Considering the aforementioned properties of *Allium sativum* necessitate investigating the effect of its extract on growth performance, nutrient intake, digestibility, and nitrogen utilisation of West African Dwarf goats artificially infected with *H. contortus.*

MATERIALS AND METHODS

Experimental site

The study was carried out at the Small Ruminant Unit, Directorate of University Farms, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The experimental site is located at latitude 71’10° N and longitude 3’2° E (Google Earth, 2025). The climate is tropical with a mean annual rainfall of 1,037 mm. The mean ambient temperature ranges from 28°C in December to 36°C in February, with a yearly average of 34°C. The vegetation represents an interphase between the tropical rainforest and the derived savannah with a yearly average humidity of 83% (Accuweather, 2025).

Experimental animals and dietary treatments

A total of twenty-five (25) growing West African Dwarf goats with an average weight of 7.18 ± 0.29, comprising both sexes, were obtained from the open market in Abeokuta. The animals on arrival were confined in the quarantine pen, which had been previously washed and disinfected using an Iodophor (Azintol) solution. The animals were treated against internal and external parasites using Ivermectin® which was administered subcutaneously to control worms at 0.5 ml per 25 kg body weight and 5 %Tetranor® (a broad spectrum and long-acting antibiotic) at 1ml per 10kg body weight for three days consecutively and an injectable multivitamins preparation were administered at the rate of 3 ml per animal. After 28 days of quarantine, the animals were housed separately in individual pens made of a raised slatted floor and corrugated iron roofing sheets with provision for water and feed troughs in individual pens. The experimental animals were grouped into five groups and offered the same diet. The animals were fed with experimental concentrate diet at 4 % of their body weight (NRC, 2007) which was adjusted weekly throughout the period of the experiment. Clean water was given *ad libitum* throughout the period of the experiment.

Experimental design

Each group was randomly assigned to one of the levels of concentration of the extracts *of Allium sativum* (garlic) at 7.5, 12.5 and 17.5 mg/ml according to the body weight of each experimental animal, while positive control was given

ALBENOR® (albendazole bolus 250 mg produced by Jubaili Agrotec) at 10 mg/ml consecutively for three days and negative control was given saline water, in a completely randomized design. The animals were drenched with the extracts and saline daily throughout the period of the experiment, while the positive control group was drenched for the first three days of the commencement of the experiment and another three consecutive days from the 29th to 31st day of the experiment.

Preparation of *Allium sativum*

Garlic (*Allium sativum*) was purchased from an open market in Abeokuta, Ogun State, Nigeria. Samples collected were carefully cleaned by removing pebbles and other debris. About 50 g of cleaned *A. sativum* was measured and milled completely with 200 ml of water with the use of a blender to obtain an aqueous extract.

Collection of *Haemonchus contortus* and infestation of lambs

Haemonchus contortus was obtained from a standard Sheep and Goats Abattior, Akinyele, Oyo State in accordance with the procedure postulated by Sonibare *et al*. (2011). About twenty abomasa of goats, which were densely burdened with *H. contortus* infestation, were recognised and gathered from the processing slab, and *Haemonchus* were drawn from abomasa contents. The abamasa worms collected were identified in accordance with the methods suggested by Zajac and Conboy (2012). The *Haemonchus* obtained were carefully washed in a nutritive medium prepared in line with the procedure of Hubert and Kerbeouf (1992) and Dryden *et al*. (2005). The medium contained 5 µl of Amphotericine B, which was used to prevent the growth of fungi that might attempt to feed on the eggs of the worms; 10 mg of yeast was added to provide nutrition for the hatched larvae, and two drops of Epsom salt solution was added for electrolyte maintenance.

Two lambs (9 months old) with an average weight of about 7.5 ± 0.22 kg were obtained from the Small Ruminant Unit, Directorate of University Farms, Federal University of Agriculture, Abeokuta, Ogun State. These lambs were orally treated for worm infestation using albendazole at 10ml per 10 kg body weight. About two hundred to two hundred and fifty (200-250) *H. contortus* each were transferred to the abomasa of the lambs through a left-sided celiotomy. After the operation, the lambs were housed in secluded pens. The animals were fed with grasses that were cut during the sunny period to avoid contamination of the worms inoculated.

Culturing of *Haemonchus contortus and inoculation of experimental animals*

Faecal samples were obtained from the donor lamb with a heavy load of Haemonchus eggs, and faecal debris was washed with distilled water and sieved in a 2 mm sieve to clear the debris. The egg suspension obtained was prepared in Petri dishes. About 5 µl of Amphotericine B was added to prevent the growth of fungi which might intend to feed on the eggs. 10 mg of yeast was prepared to provide nutrition for the hatched larvae, and Epsom salt solution was prepared for electrolyte maintenance. This was left for a period of seven days at approximately room temperature for infective larvae (L3) stage to form. This was used for the inoculation of the experimental animals by drenching. This was monitored until a specific level of infestation is accomplished.

Experimental diets

The experimental animals were raised on an intensive management system. They were placed on compounded concentrate feed daily. Cassava peels were purchased from the garri processing industry in Abeokuta city, some kilometres from the experimental site and sun dried properly. Wheat offal, palm kernel cake (PKC), bone meal, oyster shell, and salt were obtained from a reputable feed mill within the metropolis, Abeokuta, Ogun State. These ingredients were milled and used in compounding the experimental diet for the animals (Table 1).

Data collection and analysis

Growth and dry matter intake

Data was obtained on the performance of the animals in terms of weight gain, average daily weight gain (ADWG), dry matter intake (DMI), feed conversion ratio (FCR), and average daily dry matter intake.

Body weight: The weight of individual animals was measured at the commencement of the trial and subsequently weekly before offering feed throughout the experiment using a Measuretech® digital hanging scale of 50 ± 5kg capacity.

Weight gain: This was determined as the final weight at the end of the experiment minus the initial weight of the animal at the commencement of the experiment.

Weight gain = Final weight – Initial weight

Average daily weight gain (ADWG): This was determined by dividing the total weight gained by each animal by the entire period of the experiment.

Dry matter intake: This was measured by recording the quantities of feed offered and quantities left over. The difference in the dry matter of feed offered and feed leftover was taken as dry matter intake.

Table 1. Gross composition (%) of experimental concentrate diet.

Ingredients	Composition (%)
Cassava peel	28.00
Maize	10.00
Wheat offal	32.00
Palm kernel cake	27.00
Bone meal	1.00
Salt	2.00
Total	100.00
Determined analysis (%)	
Dry matter	88.50
Crude protein	16.41
Ash	10.56
Ether extract	9.18
Carbohydrate	51.35
Crude fibre	12.50
Acid detergent fibre	22.40
Neutral detergent fibre	33.60
Acid detergent lignin	5.90

Daily dry matter intake: This was carried out by dividing the total dry matter intake by the number of days of the experiment.

Feed conversion ratio: It was measured by estimating the ratio of the dry matter intake to weight gain of the animal.

$$\text{Feed conversion ratio} = \frac{\text{Daily dry matter intake}}{\text{Daily weight gain}}$$

Nutrient digestibility trial

On the 56th day of the feeding trial, three animals per treatment were transferred to the metabolism cages on the 57th day of the experiment. An adjustment period of seven days was allowed in the metabolism cage, after which the digestibility trial was carried out for five (5) days. Water was provided *ad libitum,* and concentrate feed was offered at 4 % of the live body weight of each animal. Faeces passed out by each experimental goat were collected, weighed, and recorded every day for five days before the daily feeding. This was carefully mixed together, and 20% of representative samples were taken and refrigerated at -4°C for later analysis. The feed offered and leftover samples were also collected. Composite samples of feed offered, leftover and faeces at room temperature were oven dried at 60°C for 72 hours. This was ground using a mortar and pestle and was screened through a 1 mm sieve, which was used for analysis.

The digestibility of dry matter (DM) was estimated and presented on a dry matter basis. Standard analyses of feed and faecal samples were carried out in accordance with AOAC (2000) for DM, ash, nitrogen, and ether extract (EE). The Neutral Detergent Fibre (NDF) was determined as described by Van Soest *et al*. (1991), while Acid Detergent Fibre (ADF) was analysed according to AOAC (2000) using an ANKOM200 Fibre Analyser unit. Neutral Detergent Fibre was assayed without the use of alpha amylase but with sodium sulphate. Both NDF and ADF were expressed without residual ash.

Urine collection

Urine was collected from each of the experimental animals daily for five days, which was refrigerated at -4°C for later analysis. Urine collected from each animal was carefully mixed, and a fraction of it was taken for analysis.

Statistical analysis

Data obtained were subjected to one-way Analysis of Variance in a completely randomised design. Significant ($p<0.05$) means were separated using Tukey's significant difference as contained in SPSS (2015) version 23.

Ethical consideration

The ethical guidelines established by the Committee on Animal Welfare of the College of Animal Science and Livestock Production of the Federal University of Agriculture, Abeokuta, Nigeria, were adhered to.

RESULTS AND DISCUSSION

Effect of *Allium sativum* extract on growth performance characteristics of West African Dwarf goats artificially infected with *Haemonchus contortus*

Growth performance characteristics of artificially infected West African Dwarf goats drenched with *Allium sativum* are shown in Table 2. The outcome revealed that final weight, weight gain, daily weight gain, dry matter intake, and feed conversion ratio were significantly ($p<0.05$) influenced. Final weight, weight gain, and daily weight gain were highest (10.64 kg), (2.10 kg), and (37.48 g/day), respectively, in the group of animals drenched with albendazole. Final weight obtained in animals treated with albendazole was comparable to that in animals drenched with various levels of *A. sativum* extract. However, the lowest value (8.77 kg) was obtained in animals drenched with saline water. Dry matter intake was similar and highest values in all treatment groups except for the goats treated with 12.5 mg/ml, which had the lowest value (392.05 g/day). The feed conversion ratio gave the best similar values (10.64) in the group drenched with

Table 2. Effect of *Allium sativum* extract on growth performance characteristics of West African Dwarf goats artificially infected with *Haemonchus contortus*.

Parameters	Water ml	Albendazole 10mg/ml	Extracts of *Allium sativum*			SEM	P-value
			7.5 mg/ml	12.5 mg/ml	17.5mg/ml		
Initial weight (kg)	7.18	8.54	8.41	8.07	8.20	0.29	0.628
Final weight (kg)	8.77^{b}	10.64^{a}	9.74^{ab}	9.69^{ab}	9.78^{ab}	0.33	0.042
Weight gain (kg)	1.59^{b}	2.10^{a}	1.33^{b}	1.66^{b}	1.59^{b}	0.08	0.042
Daily weight gain (g/day)	28.42^{b}	37.48^{a}	23.77^{b}	29.67^{b}	28.34^{b}	0.33	0.042
Metabolic weight gain (kgBW$^{0.75}$)	1.41	1.74	1.22	1.43	1.41	0.06	0.060
Total feed intake (kg)	21.64	22.17	21.37	19.98	21.92	3.22	0.221
Average feed intake (g/day)	386.39	395.94	381.66	356.77	391.43	5.76	0.221
Dry matter intake (g/day)	424.60^{a}	435.10^{a}	419.41^{ab}	392.05^{b}	430.15^{a}	6.33	0.044
Feed conversion ratio	14.19^{ab}	10.64^{b}	22.86^{a}	12.71^{b}	14.23^{ab}	1.84	0.011

^{a,b} = means with different superscripts along rows were significantly different (p<0.05)

albendazole, but similar (12.71) with those on 12.5 mg/ml of the extract.

The performance indices, such as final weight obtained in WAD goats treated with conventional albendazole, were comparable to values obtained in groups treated with *A. sativum* extract. This could be associated with the presence of alkaloids and phenols present in the extracts, which are capable of combating worms (Yusuf *et al*., 2023) and consequently resulting in a comparable final weight to the albendazole group. Jain *et al.* (2013) reported that tannins could hinder available protein in the gastrointestinal tract, resulting in rumen by-pass, hence disallowing nutrient availability for larva development and causing larva starvation. Tannins could also bind larvae cuticles and cause death (Hoste *et al*., 2012; Sharma and Prasad, 2014) and/or disrupt both digestive and reproductive processes (Klongisriwet *et al*., 2015), resulting in the inhibition of larva development. Additionally, *A. sativum* extract could also influence the abomasal pH, thereby making it difficult for the *H. contortus* to survive due to alterations in the chemical nature of the abomasum (Cenci *et al*., 2007).

The highest final weight (kg) obtained in all the groups except for the group treated with saline water might be due to the ability of the animals to better utilise the feed consumed for normal physiological performance as occasioned by reduced faecal worm load and the ability of the extract to improve the condition the gastrointestinal tract to favour the performance of the animals. On the other hand, the least final weight (kg) obtained in an untreated group of animals indicated the interference of *H. contortus* with the ability of the animals to optimally utilize the feed. This study showed an inverse relationship between the worm load and performance of the animals, which agrees with Hasan *et al.* (2015) who reported that the average daily weight gain of grazing goats infected with internal parasites increased by 10.3% when fed with a garlic water solution. The efficiency of albendazole in this study is in line with Strickland *et al*. (2009), where synthetic anthelmintic (abamectin) better controls *Haemonchus contortus* in artificially infected Merino sheep. Reduced weight gain in untreated animals in this study corroborates Strickland *et al*. (2009), Ayankoso *et al*. (2012a), and Sonibare *et al*. (2016), where reduced performance was obtained in sheep naturally infected with worms. The reduced growth rate observed in the untreated group will invariably increase the amount of time the animal will remain on the farm before reaching the slaughter weight, and at the same time and consequently increase the production cost (Farm Health Online 2025). Similar best values obtained for feed conversion ratio in the groups treated with albendazole and 12.5mg/ml indicated that *A. sativum* could favourably compete with conventional anthelmintic without any detrimental effect when used in the treatment of *H. contortus*. Values obtained for feed conversion ratio in this study fall within the values reported by Ekanem *et al.* (2022).

Effect of *Allium sativum* extract on nutrient intake of West African Dwarf goats artificially infected with *Haemonchus contortus*

The effect of *Allium sativum* on the nutrient intake of West African Dwarf goats artificially exposed to *Haemonchus contortus* is shown in Table 3. Every one of the components measured was not significantly (p>0.05) influenced except crude fibre intake. Animals drenched with different levels of *A. sativum* had the highest similar values for crude fibre, while the least were obtained in animals that received saline water and albendazole. The highest values obtained for crude fibre intake in all the groups drenched *A. sativum* showed that it is capable of stimulating the digestion and assimilation of fibres in the diets. This agrees with the study conducted by Ikyume *et al*. (2017), where similar results were obtained for apparent nutrient digestibility in WAD goats fed different levels of *A. sativum.* This increased crude fibre intake

Table 3. Effect of *Allium sativum* extract on nutrient intake of West African Dwarf goats artificially infected with *Haemonchus contortus.*

Parameters (g/day)	Water (ml)	Albendazole (10 mg/ml)	Extracts of *Allium sativum*			SEM	p-value
			7.5 mg/ml	12.5 mg/ml	17.5 mg/ml		
Ash	2.21	2.21	2.00	2.06	1.95	0.09	0.865
Ether extract	5.21	5.63	5.25	5.30	5.25	0.07	0.204
Carbohydrate	24.40	23.63	24.36	25.27	24.48	0.21	0.173
Crude protein	11.73	12.08	11.93	12.45	12.83	0.29	0.052
Crude fibre	5.31[b]	5.31[b]	5.62[a]	5.57[a]	5.55[a]	0.05	0.049
Dry matter	48.86	48.86	49.16	50.53	50.06	0.19	0.728

[a,b] = means with different superscripts along rows were significantly different ($p<0.05$).

Table 4. Effect of *Allium sativum* extract on nutrient digestibility of West African Dwarf goats artificially infected with *Haemonchus contortus*

Parameters (%)	Water (ml)	Albendazole (10mg/ml)	Extracts of *Allium sativum*			SEM	P-value
			7.5 (mg/ml)	12.5 (mg/ml)	17.5 (mg/ml)		
Ash	2.50	2.50	2.26	2.33	2.20	0.33	0.540
Ether extract	5.89	6.36	5.93	5.99	5.93	0.01	0.142
Carbohydrate	27.57	26.70	27.53	28.55	27.66	2.03	0.381
Crude protein	13.25	13.65	13.48	14.07	14.50	1.03	0.268
Crude fibre	6.00	6.00	6.35	6.29	6.27	0.34	0.145
Dry matter	55.21	55.21	55.55	57.10	56.56	3.33	0.645

might aid digestion, promote healthy gut microbiota in terms of stabilising intestinal flora, and improve nutrient absorption (Urban *et al*., 2025). High fibre in diets could also improve the consistency of the faeces, aid volatile fatty acid production, and reduce the incidence of diseases (Feed and Additive Magazine, 2024). A higher intake of crude fibre in the groups of animals drenched with *Allium sativum* indicates that it is included in animal diets to improve fibre utilisation and performance of the animals.

Effect of *Allium sativum* extract on nutrient digestibility of West African Dwarf goats artificially infected with *Haemonchus contortus*

The effect of *Allium sativum* on nutrient digestibility of West African Dwarf goats artificially challenged with *Haemonchus contortus* is shown in Table 4. All the parameters observed were not significantly ($p>0.05$) influenced by the drenched *Allium sativum*. This is an indication that treating intestinal worms with A. *sativum* could not hurt the digestion process of the animals, since similar outcomes were observed for those treated with conventional albendazole. Similar proportions obtained for the digestion of feed compared with those treated with albendazole suggested that the challenge of indigestion that could have occurred in the group treated with *A. sativum* extract might have been mitigated by the effect of this extract. Also, higher numerical values obtained for carbohydrate, crude protein, crude fibre and dry matter in the groups treated with *Allium sativum* extract suggested that WAD goats could be drenched with the extract has the potency to improve the digestibility of the feed and subsequent increase in performance which is in consonance with the study conducted by Cho *et al*. (2020), where the extract was observed to improve digestibility, blood profiles, and quality of the meat.

Effect of *Allium sativum* extract on nitrogen utilisation of artificially infected West African Dwarf goats with *Haemonchus contortus*

The effect of *Allium sativum* on the mean nitrogen balance of artificially infected West African Dwarf goats' is presented in Table 5. Nitrogen intake, faecal nitrogen, nitrogen balance, and nitrogen absorbed significantly ($p<0.05$) differed across the treatments. The highest (331.07 g/day) nitrogen intake was obtained in the group of animals drenched with saline water, which was comparable to the value (303.90 g/day) obtained in the group treated with albendazole; meanwhile, the least similar values were obtained in other groups drenched with different levels of the extract. The faecal nitrogen was highest (0.68 g/day) in the group of animals drenched with 12.5 mg/ml which was similar to the values (0.64 and 0.68 g/day) obtained in animals treated with saline water (0.64g/day) and 17.5 mg/ml (0.68 g/day) of the extract, while the least values (0.58 and 0.60 g/day) were obtained in animals given albendazole and 7.5 mg/ml of the extract, respectively. Nitrogen balance was highest (303.80 and 329.83 g/day) in the groups drenched with albendazole

Table 5. Effect of *Allium sativum* extract on Nitrogen utilization of West African Dwarf goats artificially infected with *Haemonchus contortus*.

Parameters (g/day)	Water (7ml)	Albendazole (10mg/ml)	Extracts of *Allium sativum* 7.5 (mg/ml)	12.5 (mg/ml)	17.5 (mg/ml)	SEM	P-value
Nitrogen Intake	331.07^{a}	303.90^{ab}	295.55^{b}	295.55^{b}	296.35^{b}	23.33	0.045
Faecal Nitrogen	0.64^{ab}	0.58^{b}	0.60^{b}	0.68^{a}	0.62^{ab}	0.01	0.042
Urinary Nitrogen	0.60	0.77	0.72	0.79	0.79	0.03	0.381
Nitrogen Output	1.24	1.34	1.33	1.47	1.40	0.03	0.268
Nitrogen Balance	329.83^{a}	303.80^{ab}	295.46^{b}	295.40^{b}	296.20^{b}	23.34	0.045
Nitrogen Absorbed	331.03^{a}	303.86^{ab}	295.51^{ab}	312.74^{ab}	296.31^{ab}	73.33	0.045
Nitrogen Retention (%)	99.97	99.97	99.97	99.97	99.97	0.00	0.118

^{a,b} = means with different superscripts along rows were significantly different (p<0.05).

and saline water, respectively, whereas least values were obtained in the groups drenched with various levels of *A. sativum* extract. Nitrogen absorbed was highest (331.03 g/day) in the group that received saline water, which was comparable to the values obtained in other treatment groups. The higher nitrogen intake reported for groups of animals drenched with saline water and albendazole might be attributed to the higher feed intake observed, which is in support of an earlier study by Adelusi *et al*. (2016) where higher nitrogen intake was observed in WAD goats with higher feed intake while fed different forages. The lower values obtained in groups treated with *A. sativum* extract could result from the phytochemicals, like tannins, which are capable of interfering with the digestion of protein in the rumen, which agrees with the findings of Brooker *et al*. (1995).

Conclusion

This study demonstrated that *Allium sativum* (garlic) extract, when administered to West African Dwarf (WAD) goats artificially infected with *Haemonchus contortus*, positively influenced growth performance characteristics such as final body weight, weight gain, daily weight gain, and feed conversion ratio. Although the conventional anthelmintic albendazole resulted in the highest performance values, goats treated with various concentrations of *A. sativum* extract showed comparable outcomes, especially in terms of feed conversion efficiency. Additionally, the extract improved crude fiber intake, potentially enhancing gut health and nutrient absorption. Nutrient digestibility was not adversely affected by the garlic extract, further supporting its safe use. However, nitrogen utilization was slightly lower in the A. sativum-treated groups, possibly due to the presence of anti-nutritional factors such as tannins that may interfere with protein metabolism.

Recommendation

Allium sativum extract shows potential as a natural alternative to synthetic anthelmintics for managing *Haemonchus contortus* in WAD goats. Its use, particularly at 12.5 mg/ml, is encouraged due to its comparable efficacy to albendazole without negative effects on digestibility or performance. Further studies should focus on optimising dosage, evaluating long-term effects on animal health and productivity, and exploring its synergy with other phytogenic additives.

CONFLICT OF INTEREST

The authors declare that they have no conflict interest.

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