Journal of Agriculture and Rural Development in the Tropics and Subtropics
Vol. 123 No. 1 (2022) 87–95

https://doi.org/10.17170/kobra-202203085849 ISSN: 2363-6033 (online); 1612-9830 (print) – website: www.jarts.info

Effects of *Petiveria alliacea* (guinea hen weed) leaf extract on fermentation parameters, nutrient digestibility and faecal worm egg count in growing West African dwarf goats

Kafayat Omowumi Adebayo*, Muhammed Abiola Mustapha, Risikat Mojisola Akinbode, Oludotun Olusegun Adelusi, Ronke Yemisi Aderinboye, Olubukola Ajike Isah

Department of Animal Nutrition, College of Animal Science and Livestock Production, Federal University of Agriculture, Nigeria

Abstract

Medicinal plants are used in animal feeding as natural antimicrobial to improve nutrient utilisation and health status of animals. This study assessed the effects of varying concentration of *Petiveria alliacea* leaf extract (PLE) on fermentation parameters, nutrient digestibility, nitrogen utilisation and faecal worm egg count of growing West African dwarf goats. Twenty- four (24) growing West African dwarf bucks with average body weight of 8.50 ± 0.55 kg were divided into four treatment groups with six bucks each in a completely randomized design. Each treatment group were administered varying concentrations (0, 2, 4 and 6 %) of PLE at 5 ml per animal and day and fed wilted *Panicum maximum* as basal feed and concentrate supplement. Results showed that oral administration of varying concentrations of PLE did not significantly ($p > 0.05$) influence ammonia-N, pH and total volatile fatty acids concentration of the rumen fluid of the experimental goats. Dry matter intake, weight gain and dry matter digestibility were also not affected ($p > 0.05$) by administration of PLE. Crude protein, NDF and ADF digestibility were higher ($p < 0.05$) in goats on 0 and 2 % concentrations and lower in those administered 4 and 6 % concentrations. Urinary N and total N excretion values were lowest in goats administered 6 % concentration of PLE. Nitrogen retained (% of N intake) was highest ($p < 0.05$) in goats administered 4 and 6 % concentration of PLE. Highest reduction (55.6 %) in faecal worm egg count was obtained at 6 % concentration of PLE. *Petiveria alliacea* leaf extract could be administered to West African dwarf goats at 4 % concentration for increased nitrogen retention and at 6 % concentration as anthelminthic.

Keywords: Anthelmintic, feed additive, livestock, medicinal plants, secondary compounds.

1 Introduction

Medicinal plants have received attention in recent years as feed additive in livestock feeding to replace antibiotics, which usage has been restricted or out rightly banned in some countries. Due to this, alternatives have been sought to synthetic drugs mainly from natural sources, especially from plants. Additives from plants are considered to be safe and cheaper. According to Atata *et al.* (2003), plants with medicinal property have made traditional medicine cheaper than orthodox medicine. Some natural products such as probiotics, dicarboxylic acids, plant extracts and exogenous enzymes have been identified as alternatives to antibiotics feed additives (Joany & Morgavi, 2007). Pattayanak *et al.* (2010) reported that herbal preparations have been identified as valuable alternatives to antibiotics and are currently been adopted in many parts of the world for treating diseases. Medicinal plants have been found to contain secondary compounds also called secondary metabolites or phytochemicals such as tannins, saponins, glycosides and essential oils which can be used to improve digestibility, nutrient absorption, and health status by elimination of pathogens in the gut and overall performance of the animal. Phytochemicals are natural growth promoters incorporated into animal feed to enhance productivity (Gadde *et al.*, 2017). According to Abdurazak *et al.* (2000) the use of browse plants contain-

* Corresponding author: yomowumi@gmail.com

Published online: 21 March 2022 – Received: 19 August 2021 – Accepted: 26 January 2022

ing secondary compounds as feed supplement for ruminants to improve their performance is gaining wide acceptance in many parts of the tropics. Phenolic compounds have been reported to exert strong anthelmintic activity (Feireira *et al*., 2013). Tannins may have beneficial effects which include anthelmintic property, direct reduction of abdominal and intestinal infections and provision of by-pass protein for absorption in the intestine (Njidda & Ikhimioya, 2010).

Petiveria alliacea is a very important plant in traditional Latin America herbal medicine where it is used as an anti-rheumatic and anti-inflammatory plant, to treat fever headache, diabetes, malaria, arthritis, skin allergies, and cancer and to induce abortion (Perez-Leal *et al*., 2006). According to Lopes-Martins *et al*. (2002) *P. alliacea* is a plant with sudorific, anti-venera, sedative, anthelmintic, emmenagogue, anaesthetic and depurative properties. It contains some phytochemical compounds like flavonoids, terpenoids and benzenoids which are commonly identified in the plant (Silva *et al*., 2018) and it is rich in Sulphur-containing compounds that possess a broad-spectrum of *in vitro* microbial activity against pathogenic fungi and bacteria at low concentrations (Guedes *et al*., 2009). An essential oil called Petiverin has also been reported to be found in the leaf and stem of *P. alliacea* (Kubec & Musa 2001; Luz *et al*., 2016). Extract and meal of *P. alliacea* leaf and root have been investigated in diets of laying hens and broiler chickens (Sobayo *et al*., 2017; Sobayo *et al*., 2018; Oyeleke *et al*., 2021a; Oyeleke *et al*., 2021b) and on rumen fermentation and methane production *in vitro* (Adebayo *et al*., 2021). There is a dearth of information on the effects of *P. alliacea* on nutrient utilisation and health of ruminants. Hence, this study seeks to investigate the effects of oral administration of *P. alliacea* leaf extract (PLE) on rumen fermentation parameters, dry matter intake, nutrient digestibility, nitrogen retention, and faecal worm egg count in West African dwarf goats.

2 Materials and methods

2.1 Study area

The study was carried out at the Small Ruminant Unit, Directorate of University farms, Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria. The University is located in the derived savannah vegetation zone of South West, Nigeria and lies on latitude 7°13'28" N and longitude 3°25'2" E with elevation of 127 m and altitude of 75 m above sea level (Google Earth, 2018). The area has a mean annual rainfall of 1,037 mm, a mean ambient temperature of about 34.7 °C and an average yearly humidity of 83 % (Metrological Station, Water Resources Management and Agro-meteorology Department, FUNAAB).

2.2 Collection and processing of Petiveria alliacea *(guinea hen weed)*

Collection and processing of *P. alliacea* was as reported by Adebayo *et al*. (2021); *P. alliacea* was harvested in a nearby village around the University. The leaves were plucked at the petiole and air dried to a constant moisture level. The dry leaves were milled to pass through a 1 mm sieve. Extraction was by a modification of the method described by Imaga & Bamigbetan (2013). About 100 ml of hot water was added to 0, 2, 4, and 6 g of the leaf powder in separate jars to obtain 0, 2, 4 and 6 % concentrations of the extract. The solution was allowed to stand for 20 minutes and thereafter sieved with Whatmann NO.1 filter paper to obtain a clear solution. The resulting different concentrations were stored in the refrigerator pending usage. The preparation was done weekly for daily use. The secondary compounds in *P. alliacea* as reported by Adebayo *et al*. (2021) are presented in table 1.

Table 1: *Secondary compounds (%) in* Petiveria alliacea *at varying concentration.*

	Concentration of P. alliacea *leaf extract*		
Parameters	*2 g/100 mL*	*4 g/100 mL*	*6 g/100 mL*
Tannin	0.0075	0.0143	0.0199
Phenol	0.0030	0.0032	0.0034
Oxalate	0.0027	0.0028	0.0030
Phytate	0.0017	0.0016	0.0016
Trypsin inhibitor	0.0101	0.0139	0.0175
Flavonoid	0.0187	0.0294	0.0414
Cyanogenic glycoside	0.000015	0.000022	0.000034
Alkaloid	0.12	0.20	0.26
Saponin	1.15	1.91	2.08

Source: Adebayo *et al*. (2021)

2.3 Experimental animals, management, and diets

Twenty-four West African dwarf bucks with an average weight of 8.50 ± 0.55 kg were purchased from villages around the University and kept in quarantine section for two weeks to monitor their health. They were maintained on wilted *Panicum maximum* and concentrate, and clean water was supplied *ad libitum*. Thereafter, they were divided into four treatment groups on weight equalisation basis and housed in individual pens. The study was divided into 2 weeks of adaptation, 10 weeks of feeding trial and 2 weeks of nutrient digestibility study. The weight of animals was taken on the first day of the experiment and fortnightly thereafter. The animals were fed 60 % wilted *P. maximum* as the basal diet and 40 % concentrate supplement at 4 % of their body

weight. The *P. maximum* was cut daily from an established pasture (which was cut back to 15 cm above ground level) after 8 weeks of re-growth and allowed to wilt for 24 hours before being fed to the animals. The concentrate diet was formulated to contain approximately 14 % crude protein with the following ingredients: Wheat offal-30 %, maize bran-27 %, palm kernel cake-20 %, rice bran -20 %, bone meal -2 % and salt-1 %. The feeds were offered in separate feeders and the animals were fed twice daily. Five millilitres (5 ml) of the varying concentrations (0, 2, 4 and 6 %) of *P. alliacea* leaf extract (PLE) were administered orally via syringe every morning to the four treatment groups respectively.

2.4 Apparent nutrient digestibility and nitrogen utilisation

This study was carried out at the end of the 70 days feeding trial for a 14-day period. All animals were transferred to a well disinfected individual metabolic cage. Known quantity of feed was offered and water was provided *ad libitum*. The first seven days was for adjustment and adaptation of the animals to the metabolic cage and the last 7 days was for collection of samples. Daily feed intake was calculated by deducting feed refusal from feed offered. Daily faecal output for each animal was collected and weigh fresh and 10 % of each day collection for each animal was dried in the oven at 60 ℃ to constant weight. At the end of the study, faecal samples from each animal were milled, pooled and stored pending analysis. Urine sample from each animal was also measured and 10 % aliquot was retained daily, bulked for each goat and stored in the freezer at −4 ℃ for subsequent analysis. Urine samples were collected in bottles containing 2 ml of 10 % H_2SO_4 solution to prevent ammonia-N loss and maintained pH below 3.0 (Chen & Gomez, 1992). Urine samples were analysed for nitrogen content and consequently nitrogen intake, nitrogen output and nitrogen retention (g day^{-1}) were calculated.

$$\text{digestibility (\%)} = \frac{\text{nutrient intake} - \text{faecal nutrient}}{\text{nutrient intake}} \times 100$$

$$\text{nitrogen absorbed} = \text{nitrogen intake} - \text{faecal nitrogen}$$

$$\text{nitrogen retained} = \text{nitrogen intake} - (\text{faecal nitrogen} + \text{urinary nitrogen})$$

2.5 Rumen fluid analysis

Rumen fluid was collected on the last day of nutrient digestibility study to determine total volatile fatty acid production and ammonia nitrogen concentration. Approximately 30 ml of rumen fluid was collected from each goat 6 hours after morning feeding and immediately after collection pH was measured using a portable pH meter (HANNA instruments HI 98153) and thereafter the fluid was freed from coarse particles by filtration through four-layers of cheese cloth. One half of the fluid was acidified with few drops of concentrated H_2SO_4 and stored frozen at −20 °C for the determination of ammonia nitrogen concentration using steam distillation procedures (Ogubai & Sereke, 1997). The second half was stored frozen at −20 °C for the determination of total volatile fatty acid (TVFA) concentration using Markham apparatus as described by Barnett & Reid (1956). This was carried out by adding 2 ml of rumen fluid together with 1 ml 10 % potassium oxalate buffer and 1 ml oxalic acid injected into the Markham apparatus, where a distillate of 100 ml was collected. This was then titrated against a standard 0.01N NaOH with 2 drops of phenolphthalein as indicator. Concentration of TVFA was then calculated using the following equation:

$$\text{TVFA (mM)} = \frac{(\text{NaOH volume} \times \text{NaOH normality} \times 1000)}{\text{rumen inoculum volume}}$$

2.6 Faecal worm egg count determination

Faecal samples of about 4 g were collected directly from the rectum of each goat at the beginning of the experiment and at two-week intervals for identification of helminth eggs using floatation techniques (Ameen *et al*., 2010). Three grams (3 g) of each faecal sample was ground and mixed with 42 mL of water. A saturated solution was poured into the mixture of faeces and water to float the eggs following the modified McMaster method (Miller *et al*., 1998). Sample obtained from this was collected and put into both compartments of McMaster counting chamber/slide and then viewed under the microscope. The number of eggs obtained within each viewed area was multiplied by 100 to get the actual number of egg per gram.

2.7 Chemical analyses

Oven dried feed and faecal samples were analysed for their proximate composition according to AOAC (2000). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin were determined according to Van Soest *et al*. (1991).

2.8 Statistical analysis

Data obtained were subjected to one-way analysis of variance in a completely randomized design using version 9.1 of SAS software (SAS 2003) with the following model:

$$Y_{ij} = \mu + T_i + e_{ij}$$

where Y_{ij} = observed variation, μ = population mean, T_i = effect of varying doses of leaf extract and e_{ij} = error term. Means were separated using Duncan's procedure of the same software.

3 Results

Table 2 shows the chemical composition of concentrate diet and *P. maximum*. The dry matter and crude protein content of the concentrate diet (93.12 % and 14.33 %) were higher than 74.35 % and 7.44 % obtained for *P. maximum*. However, neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) values of the concentrate diet (50.67 %, 25.33 % and 16.67 %) were lower than that of *P. maximum* (60.00 %, 43.67 % and 38.67 %).

Table 2: *Chemical composition (%) of concentrate supplement and* Panicum maximum.

Parameters	*Concentrate supplement*	Panicum maximum
Dry matter	93.1	74.4
Crude protein	14.3	7.4
Crude fibre	11.4	34.3
Ether extract	3.7	7.7
Ash	10.5	10.0
Nitrogen free extract	60.1	40.5
Neutral detergent fibre	50.7	60.0
Acid Detergent fibre	25.3	43.7
Acid Detergent lignin	16.7	38.7

Presented in table 3 are the fermentation parameters, dry matter intake, weight gain and apparent nutrient digestibility values of the experimental animals. Significant differences ($p < 0.05$) were observed in crude protein, ash, NDF and ADF digestibility. Crude protein, NDF and ADF digestibility were higher in goats receiving no extract and those on 2 % concentration of PLE while lower values were observed on goats receiving 4 and 6 % concentration of PLE. Higher ash digestibility values were recorded for goats administered varying concentrations of PLE and lower values were obtained for goats receiving no extract.

Table 4 shows the nitrogen balance and faecal worm egg count of West African dwarf goats administered varying concentration of PLE. All the parameters measured were significantly ($p < 0.05$) influenced by PLE administration except nitrogen intake and faecal nitrogen. Urinary nitrogen and total nitrogen excreted were lowest in goats administered 6 % concentration of PLE. However, nitrogen retained ($g\,day^{-1}$) was lower in goats receiving no PLE and higher in those administered 4 and 6 % concentration of PLE. Faecal worm egg count reduction was highest (55.56 %) in goats administered 6 % concentration of PLE and lowest (16.67 %) in goats receiving no PLE.

4 Discussion

The dry matter composition of the concentrate supplement (93.1 %) and *Panicum maximum* (74.4 %) is an indication of high nutrient density. The CP content of concentrate supplement (14.3 %) was higher than that of *P. maximum* (7.4 %). The concentrate supplement was formulated to meet the CP requirement of growing goats as recommended by (NRC, 1981). The CP of *P. maximum* could only meet the maintenance requirement of the animals. According to Pugh (2020), 7 % CP is required for maintenance of mature healthy animals while higher level of dietary CP is required for growth, gestation and lactation. Concentrate feed are usually formulated for ruminants to meet up with the inadequacy of the basal roughage diet. Fibre fractions are sources of energy for ruminants and they are also necessary for proper rumen function. The neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) values obtained for *P. maximum* and concentrate supplement were low to moderate for ruminants. These values were indicative of higher digestibility of the diet. Isah *et al.* (2015) attributed higher digestibility of a diet to low fibre concentrations. Sha Du *et al.* (2016) also reported a negative correlation between dry matter digestibility and fibre fractions of feed, that is, the higher the fibre fractions the lower the dry matter digestibility and vice versa. According to Okunade *et al.* (2014) fibre plays an important role in voluntary intake and digestibility. The NDF of *P. maximum* and concentrate supplement was below 650 $g\,kg^{-1}$ DM (65 %) threshold level at which cell wall inhibits feed intake, digestibility and animal performance (Meissner *et al.*, 1991).

The decrease in crude protein, NDF and ADF digestibility in goats administered 4 and 6 % concentration of *P. alliacea* leaf extract (PLE) may be attributed to secondary compounds in PLE which were able to exert their effect at those levels. This result confirms the report of an *in vitro* study by Adebayo *et al.* (2021). The higher digestibility obtained at 0 and 2 % concentration may suggest none availability or lower content of secondary metabolites in the diets of the animals. *P. allicea* leaf extract at 4 and 6 % concentration was able to inhibit microbial activity hence reduced CP, NDF and ADF digestibility. Antinutritional factors form a more complex structure which may decrease protein digestibility (Butts *et al.*, 2012; Lowery *et al.*, 2012). Gurbuz *et al.* (2006) and McSweeny *et al.* (2001) reported that the effects

Table 3: *Fermentation parameters, dry matter intake, weight gain and apparent nutrient digestibility of growing West African dwarf goats administered* Petiveria alliacea *leaf extract.*

	Concentrations of Petiveria alliacea *leaf extract (PLE)*					
Parameters	0 %	2 %	4 %	6 %	*SEM*	*P value*
Fermentation parameters						
pH	6.2	6.1	6.3	6.3	0.07	0.38
Ammonia-N (mg dl^{-1})	26.4	30.6	29.5	23.8	1.99	0.75
Total volatile fatty acids (mM)	44.1	49.7	45.6	46.3	1.48	0.84
Dry matter intake (g day^{-1})						
Panicum	238.9	226.1	206.6	196.2	7.52	0.09
Concentrate	155.4	148.8	166.6	151.1	5.09	0.15
Total intake	394.3	374.9	373.2	347.3	11.31	0.11
Weight gain (kg)						
Initial weight	9.0	8.6	9.0	8.5	0.16	0.56
Final weight	11.9	11.5	12.0	11.5	0.07	0.55
Total weight gain	2.9	2.9	3.0	3.0	0.01	0.27
Daily weight gain (g)	41.4	42.0	42.1	42.1	0.12	0.05
Digestibility (%)						
Dry matter	79.2	78.0	77.0	78.7	0.66	0.82
Crude protein	72.3^{a}	68.1^{a}	63.4^{b}	61.6^{b}	3.03	0.04
Ether extract	58.9	61.7	61.5	59.4	1.29	0.87
Ash	60.8^{b}	69.8^{a}	68.9^{a}	69.5^{a}	2.55	0.04
Neutral detergent fibre	70.1^{a}	66.1^{a}	58.3^{b}	61.5^{b}	3.55	0.03
Acid detergent fibre	48.5^{a}	51.7^{a}	44.0^{b}	39.5^{b}	3.39	0.03

^{ab} Means on the same row with different superscripts are significantly different ($p < 0.05$)

Table 4: *Nitrogen balance and faecal worm egg count of growing West African dwarf goats administered* Petiveria alliacea *leaf extract (PLE).*

	Concentrations of P. alliacea *leaf extract*					
Parameters	0 %	2 %	4 %	6 %	*SEM*	*P value*
Nitrogen utilisation						
N-intake (g day^{-1})	10.9	11.1	11.1	9.5	0.42	0.99
Faecal-N (g day^{-1})	1.4	1.4	1.3	1.3	0.08	0.86
Urinary-N (g day^{-1})	5.0^{a}	3.7^{b}	3.5^{b}	2.4^{c}	0.42	0.01
Total N-excreted (g day^{-1})	6.4^{a}	5.1^{b}	4.8^{b}	3.7^{c}	0.42	0.04
N absorbed (g day^{-1})	9.5^{a}	9.7^{a}	9.8^{a}	8.2^{b}	0.32	0.04
N retained (g day^{-1})	4.5^{b}	6.0^{a}	6.3^{a}	5.8^{a}	0.48	0.04
N retained (% of N intake)	40.9^{c}	52.3^{b}	56.9^{a}	60.1^{a}	3.96	0.03
Faecal egg count						
Initial faecal egg count (eggs g^{-1})	$200.^{b}$	133.0^{c}	166.7^{b}	300.0^{a}	49.94	0.004
Final faecal egg count (eggs g^{-1})	166.7^{a}	100.0^{b}	100.0^{b}	133.3^{b}	22.89	0.04
Reduction in faecal egg count (%)	16.7^{d}	25.0^{c}	40.0^{b}	55.6^{a}	9.53	0.001

^{abcd} Means on the same row with different superscripts are significantly different ($p < 0.05$)

of tannin are associated with their ability to combine with dietary proteins, cell wall polymers such as cellulose, hemicellulose and pectin as well as minerals thus either retarding or preventing their microbial digestion. According to Jemiseye *et al.* (2019) tannin render protein unavailable for digestion in the rumen due to formation of complexes thereby decreasing rumen ammonia concentrations and inhibiting fermentation of structural carbohydrates. Decreased feed digestibility had been reported with phytogenic additives (Aderao *et al.*, 2018; Joch *et al.*, 2019). Reduced CP digestibility may

suggest that there will be an increase in available protein at the lower gut for enzymatic digestion and absorption. Protein digested and absorbed in the lower gut as amino acids is utilized by the animals for productive purposes (growth, milk production and so on).

The reduction observed in urinary-N, total N excreted and N-absorbed in goats administered 6 % PLE can be attributed to secondary compounds in PLE, which were able to reduce degradation of protein to ammonia-N by microbes in the rumen thus its availability in the lower tract for productive purposes. Reduced urinary-N excretion suggests reduced ruminal N degradability of the diet possibly due to protective action of secondary compounds on protein in the rumen. Plants containing tannin and saponin have been reported to reduce ammonia production in the rumen (Patra & Saxena, 2010; Bodas *et al*., 2012) and invariably urinary-N. The trend observed in this study complement the findings of Mahgoub *et al*. (2008) that animals fed higher levels of tannins tend to produce higher levels of protein in the faeces and lower nitrogen levels in the urine. Positive N balance was obtained for all the animals in the treatment groups. An indication of adequate nutrient levels in the diets to meet the protein requirement of the animals. Nitrogen retention is the proportion of nitrogen utilized by animals from the total nitrogen intake for body processes (Saka *et al*., 2020). Reduced N excretion and greater N retention recorded at 4 and 6 % concentrations indicate superior protein metabolism, availability and utilisation by the goats. Alves *et al*. (2014) asserted that greater N retention may indicate better utilisation of dietary N and possibly higher muscle deposition and weight gain. The weight gain of animals at 4 and 6 % concentration was numerically higher than at other concentrations. This implies that administration of PLE at 4 and 6 % concentration may improve weight gain in animals.

The highest reduction obtained in faecal worm egg count at 6 % concentration could suggest that the concentration of secondary compounds at the level was more sufficient in eliminating the worms than other concentrations. Anthelmintic activity of root and stem extract of *P. alliacea* has been reported (Lopez-Martins *et al*., 2002; Flota-Burgos *et al*. 2017; Rosado-Aguilar *et al*., 2020). These authors also attributed the anthelmintic activity to the presence of secondary compounds in the plant. Tannins have been reported to have effect on internal parasites (Butter *et al*., 2000; Khan & Diaz-Hernandez, 2000) and provide by-pass-protein for absorption in the intestine (Njidda & Ikhimioya, 2010). Anthelmintic activity of phenols have also been reported (Feireira *et al*., 2013, Udoha *et al*., 2015). The results obtained from the study indicates that PLE could be used as anthelmintic for goats at 6 % concentration. This will reduce the cost of production as it will eliminate the purchase of anthelmintics by poor farmers in developing countries and also solve the problem of resistance of worms to some conventional anthelmintics. The overall effect will be increased productivity and high economic gain to farmers. Diseases caused by helminths in small ruminants in the tropics and subtropics have been reported to result in poor growth (Mini, 2012), lower productivity (Ombasa *et al*., 2012), mortality (Mohammed *et al*., 2013) and high economic losses (Alemu *et al*., 2014). *P. alliacea* is within the reach of farmers as the shrub is commonly found in most farms and bushes in South-West Nigeria. Camargo (2007) reported that *P. alliacea* is a wild and perennial shrub that grows in Africa and tropical America.

5 Conclusions

Extract of *P. alliacea* leaves improved nitrogen retention in goats at 4 % concentration but with highest reduction in faecal worm egg count at 6 % concentration. This implies that for increased nitrogen retention and invariably weight gain the extract can be administered to goats at 4 % concentration but as anthelmintic it can be administered at 6 % concentration. Further investigation is recommended to determine its effect on blood profile, carcass/meat quality and immune response of the animals.

Acknowledgements

The authors acknowledge the support of Mr. Ibrahim Oguntusi of the Directorate of University farms during the field trial.

Conflict of interest

The authors declare that they have no conflict of interest.

References

Abdulrazak, S. A., Fujihara, T., Ondiek, J. K., & Orskov, E. R. (2000). Nutritive evaluation of some acacia tree leaves from Kenya. *Animal Feed Science and Technology*, 85, 89–98.

Adebayo, K. O., Olagoke, F. T., Akinbode, R. M., & Aderinboye, R. Y. (2021). Effect of *Petiveria alliacea* (guinea hen weed) leaf extract on methane production and rumen fermentation *in vitro*. *Livestock Research for Rural Development*. 33(2). http://www.lrrd.org/lrrd33/2/yomo3327.

Aderao, G. N., Sahoo, A., Bhatta, R. S., Kumawat, P. K., & Soni, L. (2018). *In vitro* rumen fermentation kinetics, metabolite production, methane and substrate degradability of polyphenol rich plant leaves and their component complete feed blocks. *Journal of Animal Science and Technology*, 60, 26. https://doi.org/10.1186/s40781-018-0184-6.

Alemu Z., Kechero Y., Kebede A., & Mohammed A. (2014). Comparison of the *in vitro* inhibitory effects of doses of tannin rich plant extracts and ivermectin on egg hatchability, larvae development and adult mortality of *Haemonchus contortus*. *Acta Parasitologica Globalis*, 5, 160–168.

Alves, E. M., Magalhaes, D. R., Freitas, M. A., dos Santos, E. Pereira, M. L. A., & Pedreira, M. D. (2014). Nitrogen metabolism and microbial synthesis in sheep fed diets containing slow-release urea to replace the conventional urea. *Acta Scientiarum. Animal Sciences*, 36(1), 55–62.

Ameen, S. A., Adedeji O. S., Ojedapo L. O., Salihu T., & Fabusuyi C. O. (2010). Anthelmintic potency of pawpaw (*Carica papaya*) seeds in West African Dwarf sheep. *Global Veterinaria* 5(1), 30–34.

AOAC (2000). Official methods of analysis of AOAC. International 17th edition; Gaithersburg, MD, USA Association of Analytical Communities.

Atata R. F., Sani A., & Ajewole S. M. (2003). Effects of stem Bark Extracts of *Enantia chloranta* on some clinical isolates. *Biokemistri*, 15(2), 84–92.

Barnett, J. G. A., & Reid, R. L. (1956). Studies on the production of volatile fatty acids from the grass by rumen liquor in an artificial rumen. *Journal of Agricultural Science*, 48, 315–321.

Bodas, R., Prieto, N., García-González, R., Andrés, S., Giráldez, F. J., & López, S. (2012). Manipulation of rumen fermentation and methane production with plant secondary metabolites. *Animal Feed Science and Technology*, 176, 78–93.

Butter, N. L., Dawson J. M., Wakelin, D., & Buttery, P. J. (2000). Effect of dietary tannin and protein concentration on nematode infection (*Trichostrongylus colubriformis*) in lambs. *Journal of Agricultural Science*, 134, 89–99.

Butts, C. A., Monro, J. A., & Moughan, P. J. (2012). *In vitro* determination of dietary protein and amino acid digestibility for humans. *British Journal of Nutrition*, 108, 282–287.

Carmago, M. T. A. (2007). Etnopharmacobotanical contribution to a survey on *Petiveria alliacea* L. – Phytolaccaceae- ("amansa senhor") and to the hipoglucemic activity related to mental disturbs. *Dominguezia*, 23(1), 21–27.

Chen, X. B., & Gomes, M. J. (1992). Estimation of microbial protein supply to sheep and cattle based on urinary excretion of purine derivatives: an overview of the technical details. International feed resource unit, Rowett Research Institute, Bucksburn, Aberdeen, UK. Occasional Publication. 21 p.

Du, S., Xu, M., & Yao, J. (2016). Relationship between fibre degradation kinetics and chemical composition of forages and by-products in ruminants. *Journal of Applied Animal Research*, 44(1), 189–193. https://doi.org/10.1080/09712119.2015.1031767.

Feireira, L. E., Castro, P. M. N., Chagas, A. C. S., Franca, S. C., & Beleboni R. O. (2013). *In vitro* anthelmintic activity of aqueous leaf extract of *Annona muricata* L. (Annonaceae) against *Haemonchus contortus* from sheep. *Exp.Parasitol*., 134, 327–332.

Flota-Burgos, G. J., Rosado-Aguilar, J. A., Rodriguez-Vivas, R. I., & Arjona-Cambranes, K. A. (2017). Anthelmintic activity of methanol extracts of *Diospyros anisandra* and *Petiveria alliacea* on Cyathostomin (Nematoda: Cyasthominae) larva development and hatching. *Veterinary Parasitology*, 248, 74–9.

Gadde, U., Kim, W. H., Oh, S. T., & Lillehoj H. S. (2017). Alternatives to antibiotics for maximizing growth performance and feed efficiency in poultry: a review. *Animal Health Research Reviews*, 18, 26–45.

Google Earth, (2018). http://www.goggle.earth.

Guedes, R. C. M., Nogueira, N. G. P., Fuscu- Almeida, A. M., Souza, C. R. F., & Oliveira, W. P. (2009). Atividade antimicrobiana de extratos brutos de *Petiveria alliacea* L. Latin *American Journal of Pharmacy*, 28(4), 520–524.

Gurbuz, B., Ipek, A., Basalma, D., Sarihan, E. O., Sancak, C., & Ozcan, S. (2006). Effect of Diurnal Variability on Essential Oil Composition of Sweet Basil (*Ocimum basilicum* L.). *Asian Journal of Chemistry* 18(1), 285–288.

Imaga, N.O.A., & Bamigbetan, D.O. (2013). *In vivo* biochemical assessment of aqueous extract of *Vernonia amygdalina* (Bitter leaf). *International Journal of Nutrition and Metabolism*, 5(2), 22–27.

Isah, O. A., Okunade, S. A., Aderinboye, R. Y., & Olafadehan, O. A. (2015). Effect of browse plant foliage supplementation on the performance of bukling goats fed threshed sorghum top basal diet. *Tropical Animal Health and Production*, 47(6), 1027–1032.

Jemiseye, F. O., Akinlade, J. A., Ogunwole, O. A., & Adediji, B. S. (2019). *Piliostigma thonningii* leaves as dry season feed supplement for West African dwarf goats. *Nigerian Journal of Animal Production*, 46(2), 276–283.

Joch, M., Kudrna, V., Hakly, Y., Bozik, M., Homolka, P., Illek, J., Tyrolova, Y., & Vyborna, A. (2019). *In vitro* and *in vivo* potential of a blend of essential ol compounds to improve rumen fermentation and performance of dairy cows. *Animal Feed Sci. and Technology*, 251, 176–186.

Jouany, J. P., & Morgavi, D. P. (2007). Use of natural products as alternatives to antibiotic feed additives in ruminant production. *The Animal Consortium*, 1(10), 1443–1466.

Khan, L. P., & Diaz-Hernandez, A. (2000). Tannins with anthelmintic properties. In: Brooker, J. D. (Ed.). *Tannins in livestock and human nutrition*. Adelaide, Australia: Australian Centre for International Agricultural Research. pp. 130–140.

Kubec, R., & Musah R. A. (2001). Cysteine sulfoxide derivatives in *Petiveria alliacea*. *Phytochemistry*, 58, 981-985.

Lopes-Martins, R. A. B., Pegoraro, D. H., Woisky, R., Penna, S. C., & Sertie, J. A. A. (2002). The anti-inflammatory and analgesic effects of a crude extract of *Petiveria alliacea* L. (Phytolaccaceae). *Phytomedicine*, 9(3), 245–248.

Lowery, L., Edel, J. F., & McBride, I. M. (2012). Dietary Protein and Strength Athletes. *Strength and Conditioning Journal*, 34, 26–32.

Luz, D. A., Pinheiro, A. M., Silva, M. L., Monteiro, M. C., & Prediger, R. D. (2016). Ethnobotany, phytochemistry and neuropharmacological effects of *Petiveria alliacea* L. (Phytolaccaceae): A review. *Journal of Ethnopharmacology*, 185, 182–201.

Mahgoub, O., Kadim, I. T. Tageldin, M. H., Al-Marzooqi, W. S., Khalaf, S.Q., & Ambu A. A. (2008). Clinical profile of sheep fed non-conventional feeds containing phenols and condensed tannins. *Small Ruminant Research*, 78, 115–122.

McSweeney, C. S., Palmer, B., Mcneill, D. M., & Krause, D. O. (2001). Microbial Interactions with Tannins: Nutritional Consequences for Ruminants. *Animal Feed Science and Technology*, 91, 83–93.

Meissner, H. H., Viljoen, M. O., & Van Niekerk, W. A. (1991). Intake and Digestibility by Sheep of Anthephora, Panicum, Rhodes and Smuts Finger Grass Pastures. In: *Proceedings of the 4th International Rangeland Congress*, 22–26 April 1991, Montpellier, France, pp. 648–649.

Miller, J. E. M., Bahirathan, L. S., Lamarie, G. F., Hembry, T. M., & Barras, R. S. (1998). Epidemiology of gastrointestinal nematode parasitism in Suffolk and Gulf Coast native sheep with special emphasis on relative susceptibility to *Haemonchus concortus* infection. *Veterinary parasitology*, 74, 55–74.

Mini, K. P. (2012). In vitro *assessment of anthelmintic effect of Arstolochia species plants against* Haemonchus contortus. PhD Thesis, Tamil Nadu Veterinary and Animal Sciences University, Chennai, 51 p.

Mohammed, A., Wossene, A., Giday, M., Tilahun, G., & Kebede, N. (2013). *In vitro* anthelminthic activities of four medicinal plants against *Haemonchus contortus*. *African Journal of Plant Science*, 7, 369–373.

Njidda, A. A,. & Ikhimioya, I. (2010). Correlation between chemical composition and *in vitro* dry matter of leaves of semi-arid browses of North-Eastern Nigeria. *American-Eurasian Journal of Agriculture and Environmental Science*, 9(2), 169–175.

NRC (1981). Nutrient requirement of goats: angora, dairy and meat goats in temperate and tropical countries. National Academy of Sciences, National Research Council, Washington DC.

Ogubai, M., & Sereke, B.S. (1997). Analytical methods for feeds, animal excrements and animal tissues. Nutrition Laboratory, ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia. 90 p.

Okunade, S. A., Isah, O. A., Aderinboye, R. Y., & Olafedehan, O. A. (2014). Assessment of chemical composition and *in vitro* degradation. Profile of some guinea savannah browse plants of Nigeria. *Tropical and Subtropical Agroecosystem*, 17, 529–538.

Ombasa, O., Karem, P. G., Rukunga, G., Mbaria, J., Keriko, J. M., Njonge, F. K., & Owuor, B.O. (2012). *In-vitro* antihemintic effects of two Kenyan plant extracts against *Haemonchus contortus* adult worms. *International Journal of Pharmacological Research*, 2, 113–116.

Oyeleke, M. A., Adeyemi, O. A., Egbeyale, L. T., Sobayo, R. A., Obasa, O. A., & Okukenu, O. A. (2021a). Growth performance, blood indices and intestinal organ development of pullet chicks administered aqueous extract of guinea hen weed (*Petiveria alliacea*). *Slovak Journal of Animal Science*, 54(1), 1–55.

Oyeleke, M. A. Adeyemi, O. A., Egbeyale, L. T., Sobayo, R. A., & Olaifa, R.O. (2021b). Response of laying hens to aqueous extract of *Petiveria alliacea* root and leaf. *Scientia Agriculturae Bohemica*, 52(2), 29-38. https://doi.org/10.2478/sab-2021-0004.

Pattanayak, P., Behera, P., Das, D., & Panda, S. K. (2010). *Ocimum gratissimum* Linn. A reservoir plant for therapeutic applications: An overview. *Pharmacognosy Reviews*, 4(7), 95–105.

Patra, A. K., & Saxena, J. (2010). A new perspective on the use of plant secondary metabolites to inhibit methanogenesis in the rumen. *Phytochemistry*, 71, 1198–1222.

Perez-Leal, R., Garcia-Mateos, M. R., Martinez-Vasquez, M., & Soto-Hernandez, M. (2006). Cytotoxic and antioxidant activity of *Petiveria alliacea* L. (Actividadcitotosicay antioxidante de Petiveriaalliacea L.) *Revista Chapingo Serie Horticulyuta*, 12(1), 51–56.

Pugh, D. G. (2020). Nutritional Requirement of goats. MSD Veterinary Manual. https://www.msdvetmanual.com/management-and-nutrition/nutrition-goats/nutritional-requirements-of-goats.

Rosado-Aguilar, J. A., Flota-Burgos, G. J., Rodriguez-Vivas, R. I., Borges-Argaez, R., Gamboa-Angulo, M., & Martinez-Ortiz-de-Montellano, C. (2020). Anthelmintic activity of *Petiveria alliacea*, *Bursera simaruba y Casearia corymbose* collected in two seasons on *Ancylostoma caninum, Haemonchus placei* and *Cyathostomins*. *Acta Scientific Veterinary Sciences*, 2(12), 12–24.

SAS (2003). Statistical Analysis Systems, The SAS system for windows. Release 9.1, SAS Institute Inc., Cary, North Carolina, U.S.A.

Saka, A. A., Sowande, O. S., Oni, A. O., Yusuf, A. O., Adebayo, K. O., & Oyebade, A. O. (2020). Influence of diets containing graded levels of raw and fermented malted sorghum sprouts on rumen ecology, apparent nutrient digestibility and nitrogen utilization of West African dwarf goats. *Malaysian Journal of Animal Science*, 23(1), 41–63.

Silva, J. P., do Nascimento, S. C., Okabe, D. H., Pinto, A. C., de Oliveira, F. R., da Paixão, T. P., Souza Siqueira, M. L., Baetas, A. C., & de Andrade, M. A. (2018). Antimicrobial and Anticancer Potential of *Petiveria alliacea* L. *Journal of Pharmacognosy and Natural Products*, 12, 85–93.

Sobayo, R. A., Okonkwo, I. J., Sanwo, K. A., Oso, O. A., Eruvbetine, D., Oguntona, E. B., & Muhammed, S. B. (2017). Effect of dietary supplementation of guinea hen weed (*Petiveria alliacea*) leaf and root meals on nutrient utilization and intestinal morphology of finishing broiler chicken. *Nigerian Journal of Animal Science*, 19(1), 144–156.

Sobayo, R. A., Okonkwo, I. J., Muhammed, S. B., Sanwo, K. A., Oso, O. A., & Sogunle, O. M. (2018). Haematological and serum indices of finishing broiler chickens fed graded levels of guinea hen weed (*Petiveria alliacea*). *Bulletin of Animal Health and Production in Africa*, 66(2), 299–312.

Udoha, M. U., Okolie, N. J., & Ijioma, S. N. (2015). Anthelmintic activity of *Ocimum gratissimum* leaf extract in *Heligmosomoides bakeri* infected experimental mice. *Annals of Biological Sciences*, 3(4), 1–7.

Van Soest P. J, Robertson J. B., & Lewis B. A. (1991). Methods for dietary fiber, neutral detergent fiber and nonstarch polysaccharides in relation to animal Nutrition. *Journal of Dairy Science*, 74, 3583–3597.