Evaluation of Anthelmintic Attributes of Moringa and Bamboo Leaves in Gastrointestinal Nematode-Infested West African Dwarf Goats

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Abstract: The anthelmintic attributes of moringa and bamboo leaves were evaluated using 18 gastrointestinal nematode-infested West African Dwarf goats (nine males and nine females; mean weight = 9.5±0.5 kg) in a 12 week feeding trial with groundnut hay as the reference diet in a complete randomized design. Total and condensed tannins of moringa and bamboo leaves were quantified. Feed intake, weight changes, feed conversion ratios, faecal egg counts and packed cell volumes of the goats were monitored. The animals were thereafter slaughtered for gastrointestinal worm counts and carcass characterization. No condensed tannins were detected in bamboo leaves while they constituted 0.1% of moringa leaves. There were no ($p>0.05$) dietary effects on dry matter intake. Moringa-substitution of groundnut hay produced a significant ($p<0.05$) reduction in feed conversion ratio (18.0 vs. 27.4 g feed g^{-1} live-weight gain) while bamboo-substitution led to a significant ($p<0.05$) increase (45.7 vs. 27.4 g feed g^{-1} live-weight gain). The final mean faecal egg counts were between 334-384 eggs g^{-1} of faeces/animal, representing a drop of at least 65% but were not ($p>0.05$) affected by dietary treatments. The mean worm burden pattern after slaughter indicated mixed infestations with no significant ($p>0.05$) diet effects. Moringa substitution of groundnut hay produced significant ($p<0.05$) increases in warm carcass weight and dressing percentage (5.2 vs. 4.4 kg; 47.3 vs. 40.5%). Bamboo and moringa leaves contained no condensed tannins of anthelmintic significance. However, complementing groundnut hay, the feed resource of choice in The Gambia with moringa foliage (50:50 ratio), appears promising in improving resilience of West African Dwarf goats to the negative effects of gastrointestinal nematode infections and maintaining productivity under the parasitic challenge.

INTRODUCTION

Farm animals are a major source of livelihood for most people in Africa. A report by the Food and Agriculture Organization (FAO, 1997) indicates that in The Gambia, livestock contributes approximately 24% of the agricultural gross domestic product with sheep and goats playing a major role in the rural economy with groundnut hay, the major residue after groundnut harvest, being the traditional feed resource of choice for ruminants (Nouala *et al*., 2006).

There are many important diseases of sheep and goats but none is as ubiquitous or present as direct a threat to the health of goats as parasitic nematodes of the digestive tract (Kaplan, 2004; Hoste *et al*., 2005). These include species of *Haemonchus, Cooperia, Bunostomum, Gaigeria, Oesophagostonum, Trichuris* and *Trichostrongylus* and they inhabit the different segments of the digestive tract (Hoste, no date). Clinical signs of parasitism include extensive scouring, severe loss of appetite, dehydration, anaemia/oedema and eventual death (Houdijk and Kyriazakis, 2007). The researchers observed that nematode infections can be very costly, as growth performance can be reduced by 50% or more. The animals reportedly (Houdijk and Kyriazakis, 2007) take longer to reach market weight with reduced carcass quality, higher feeding costs and reduced market price. The usual mode of control of the gastro-intestinal nematodes is based on the repeated use of anthelmintics, either for prevention of infection or to cure the animals (Hoste *et al*., 2005). However, the development of anthelmintic resistance in worm populations is now a worldwide phenomenon in constant expansion and is particularly prevalent in goats (Ackson and Coop, 2000; Jackson and Coop, 2000; Kaplan, 2004), although the phenomenon has also been reported in cattle and sheep (Prichard, 1994; Waller, 1994; Pomroy *et al*., 2002). The epidemiology of helminth infections in sheep and goats has been well studied in The Gambia (Greenwood and Mullineaux, 1989; Fritsche *et al*., 1993; Ndao *et al*., 1995; Osaer *et al*., 1999). An epidemiological study based on post-mortem examinations carried out over one year by Fritsche *et al.* (1993) showed that over 95% of sheep and goats in The Gambia are infected with gastrointestinal nematodes. Reports (Geerts and Dorny, 1996; Ba and Geerts, 1998) also exist of the development of anthelmintic resistance in worm populations among small ruminants in The Gambia. It is known that producers can no longer rely on drugs alone to control these internal parasites (Hale, 2006). The phenomenon has stimulated a global search for alternative solutions which is also supported by an enhanced public concern for more sustainable systems of production, less reliant on chemotherapy (Waller, 1999; Jackson, 2000). An increasing number of studies indicate that nutrition could affect parasitism not only through quantitative variations of different diet components but also by the presence of some qualitative compounds in plants consumed by herbivores and particularly secondary metabolites (Athanasiadou *et al*., 2003). Alternative parasite management strategies using forages containing condensed tannins have been suggested (Niezen *et al*., 1995; Min *et al*., 2002).

Moringa oleifera (moringa) and *Oxytenanthera abyssinica* (bamboo) foliages are suspected to possess some antihelmintic properties, attributable to the probable presence of condensed tannins at beneficial levels to goats (Akinbamijo, 2006). The potentials of moringa and bamboo leaves at 75 and 50% moringa inclusion levels as nutritional supplements in West African Dwarf (WAD) goats' diets have been studied (Asaolu *et al*., 2009a,b; Asaolu *et al*., 2010a). Asaolu *et al*. (2010b) reported that feeding groundnut hay along with moringa leaves in the same ratio significantly improved nitrogen intake and retention as well as total digestible nutrients.

This study evaluated the anthelmintic effects of feeding the foliages of moringa and bamboo in the same ratios with groundnut hay with WAD goats that were naturally-infested with gastro-intestinal nematodes. The performance indices were feed intake, weight change, packed cell volume, faecal egg count *in utero* worm burdens and carcass characteristics.

MATERIALS AND METHODS

The study was conducted at the Small Ruminant Unit of the International Trypanotolerance Centre (ITC), Kerr Serrigne, The Gambia; a country situated on the Atlantic Coast at the Western tip of West Africa and surrounded by Senegal on three sides (Bojang, 1999). Kerr Serrigne lies between the latitude 13 and 16°45'W (Diack *et al*., 2005). The study was conducted from the end of the rainy season in November 2007 through the early part of the dry season in January 2008.

Moringa (MOR) and Bamboo (BAM) leaves were freshly harvested after 8 weeks of re-growth from established plots and stands within ITC. Groundnut Hay (GNH) was purchased from a local livestock feed market. Experimental Diet 1 (50MOR:50GNH) comprised of 50% of moringa foliage while Diet 2 (50BAM:50GNH) comprised of 50% of bamboo foliage, with the remaining 50% in each of Diets 1 and 2 consisting of 50% groundnut hay. Diet 3 (100GNH), the reference diet was 100% groundnut hay.

About 18 WAD weaned goats (nine male and nine female), weighing 9.5 (±0.5) kg were purchased from some local small ruminant markets and quarantined for three weeks as described by Asaolu *et al*. (2010b). The goats were subsequently allowed free access for 6 weeks to *Panicum maximum* paddocks that had been contaminated with L_3 larvae of gastrointestinal nematodes from small ruminant faeces collected from a local abattoir in order to facilitate their uniform exposure to intestinal nematode larvae typical of small ruminants in the area. The goats were thereafter grouped into three of six each, with a balance maintained for weight, sex and intestinal nematode infestation levels and thereafter allotted to the three experimental diets in a 12 weeks feeding trial in individual pens equipped with feeding and watering facilities, preceded by a 14 days adaptation period to the experimental diets, using a Complete Randomized Design (CRD). The goats were offered the experimental diets at 4% of their body weight (DM basis). Clean, fresh water was provided for all the animals daily. Growth rate was monitored by regressing growth data against time. Daily feed offer and refusal were weighed for each animal to estimate daily feed intake. At the commencement and subsequently every fortnight, rectal fecal samples were collected for Faecal Egg Counts (FEC) using the McMaster technique with a sensitivity of 100 EPG (Thienpont *et al*., 1979). Jugular vein blood samples were similarly collected with EDTA-coated vacutainer tubes (4.5 mL) and PCV levels were measured as an estimation of anemia using the capillary microhematocrit centrifugation following the procedures of Hansen and Perry (1994).

At the end of the feeding trial, all the experimental goats were weighed (slaughter body weight, SBW) and decapitated by cutting the carotid arteries and jugular veins. Blood was drained into a bucket and blood volume from each decapitation was measured. The decapitated animals were flayed by gently tearing of skin from the carcass to ensure that fat and muscle tissues did not adhere onto the skin (Okello *et al*., 1996). After flaying, the head was removed at the occipital-atlas articulation and the feet cut off between the cannon and the pastern bones. All the internal organs along with their fat depots were also removed. The Warm Carcass (WCW) and some non-carcass components were thereafter weighed. The carcass was chilled at 4°C for 24 h and the Cold Carcass Weight (CCW) was measured. Dressing Percentage (DP) was defined as the WCW expressed as a percentage of SBW and Cooler Shrinkage (CS) was calculated as the proportion of the difference between WCW and CCW to WCW (Sebsibe *et al*., 2007).

The gastro-intestinal tracts of all the sacrificed goats were collected for worm counting *in utero*. Worm counting procedures for the abomasum and the small intestine were as described by Eysker and Kooyman (1993) while the procedure of Moyo (2006) was used for that of the large intestines.

Feed samples were analyzed for their proximate components by methods of AOAC (1997). The fibre fractions were determined with ANKOM Technology Methods (2001a, b). Potassium, sodium, calcium and phosphorus concentrations were determined with the aid of an Atomic Absorption Spectrophotometer.

Freshly harvested moringa and bamboo leaves were air-dried and ground to a fine powder and extracted with 80% aqueous methanol. The final ratio after two cycles of sonication and centrifugation was 10 mg dry matter mL^{-1} of solvent. Total phenols were determined by the Folin assay (Makkar *et al*., 1993) with tannic acid as calibration standard. Total tannins were determined after precipitation with polyvinyl pyrrolidone, PVPP in combination with the Folin assay (Makkar *et al*., 1993). Condensed tannins were assayed according to Porter *et al*. (1985).

The data collected on each animal performance index were subjected to Analysis of Variance (ANOVA) using SAS (1998) package. Significant means were separated using the Duncan's Multiple Range Test of the same package.

RESULTS AND DISCUSSION

Table 1 shows the nutrient and mineral compositions of the experimental feed components/diet compositions. The Crude Protein (CP) contents ranged from 135.2-221.6 g kg^{-1}DM for Groundnut Hay (GNH) and Moringa (MOR) leaves respectively. The Neutral Detergent Fibre (NDF) and Acid Detergent Fibre (ADF) values were both least for MOR (278.6; 289 g kg^{-1}DM) and were both highest for Bamboo (BAM) leaves (687.6; 422.5 g kg^{-1} DM). MOR contained higher levels of K and Ca than the other two experimental feed components. Na was found at a higher concentration in BAM while P was found at higher concentration in GNH. Both MOR and BAM leaves were observed to contain some phenolic compounds but at very low levels, with an apparently higher level (3.0%) in MOR leaves (Table 2). Total tannins were observed to be present at 0.9 and 0.1% in MOR and BAM leaves respectively. Condensed tannins were observed at a very low level (0.1% DM; Table 2) in MOR leaves but were absent in BAM leaves.

No significant ($p>0.05$) differences were observed in Dry Matter Intake (DMI) values which ranged from 300-320 g/animal/d for 100GNH and 50MO:50GNH, respectively (Table 3). Significant ($p<0.05$) differences were however observed in total and daily weight gains with higher values in favour of MO substitution relative to BA substitution of GNH with Average Daily Gain (ADG) values ranging from 6.8 (50BA:50GNH) to 17.0

Table 1: Nutrient and mineral compositions (g kg^{-1}DM) of experimental feed components/diet compositions fed to WAD goats naturally infested with gastrointestinal nematodes

Nutrients/ minerals	Feed components/experimental diets: MOR	GNH	BAM	50 MOR: 50 GNH (Diet 1*)	50 BAM: 50 GNH (Diet 2*)	100% GNH (Diet 3*)
DM (g kg^{-1})	250.00	870.00	450.00	560.00	660.00	870.00
g k g^{-1}DM						
CP	221.60	135.20	145.20	179.60	139.40	135.20
EE	66.80	26.70	22.50	47.30	24.90	26.70
CF	110.40	229.70	233.30	168.10	231.20	229.70
NFE	413.30	463.60	427.70	437.70	448.50	463.60
ASH	132.30	78.00	115.20	105.90	93.70	78.00
NDF	279.60	452.10	687.60	363.40	551.30	452.70
ADF	289.00	403.00	422.50	344.40	411.20	403.00
Potassium	12.60	10.90	11.20	11.80	11.10	10.90
Sodium	2.80	1.10	3.40	1.90	2.00	1.10
Calcium	19.70	12.60	7.00	16.30	10.30	12.60
Phosphorus	1.30	3.50	1.40	2.40	2.60	3.50

MOR = Moringa leaves, GNH = Groundnut Hay, BAM = Bamboo leaves *Nutrient compositions were computed for mixed experimental diets

Table 2: Phenol and tannin contents (DM%) of moringa and bamboo leaves used as complements to groundnut hay basal diet for WAD goats naturally infested with gastrointestinal nematodes

Samples	Parameter (DM%): Total phenols	Total tannins	Condensed tannins
Moringa leaves	3.0	0.9	0.1
Bamboo leaves	1.0	0.1	0.0

Table 3: Mean values of performance indices of West African Dwarf goats naturally-infested with gastrointestinal nematodes fed a sole diet of groundnut hay and its combinations with moringa and bamboo leaves

Items	Experimental diets: 50MO: 50GNH (Diet 1)	50BA: 50GNH (Diet 2)	100GNH (Diet 3)	SEM
Mean initial weight (kg)	9.50	9.00	10.00	0.40
Mean final weight (kg)	10.90^a	9.60^b	10.90^a	0.30
Total BW gain (kg)	1.40^a	0.60^c	0.90^b	0.10
ADG (g/animal/day)	17.00^a	6.80^c	11.00^b	2.10
Mean DMI (g/animal/d)	320.00	310.00	300.00	7.50
FCR	18.80^c	45.70^a	27.40^b	2.80
Mean PCV (haematocrit/animal)	26.00	21.00	27.00	2.60
Initial mean FEC (eggs/g/animal)	1190.00	1060.00	1100.00	28.50
Final mean FEC (eggs/g/animal)	334.00	370.00	384.00	25.00
% Drop in FEC	71.90	65.10	65.10	5.80

^{abc}Means in the same row with different superscripts are significantly (p<0.05) different. MO = Moringa foliage; BA = Bamboo foliage; GNH = Groundnut hay; BW = Body weight; ADG = Average daily gain; DMI = Dry matter intake; FCR = Feed conversion ratio; PCV = Packed cell volume; SEM = Standard error of the mean

g/animal/day (50M:50GNH). The observed Feed Conversion Ratios (FCR), ranging from 18.80-45.70 for 50MO:50GNH and 50BA:50GNH diets, respectively indicated that animals on 50MO:50GNH diet consumed significantly (p<0.05) less feed than those fed the other two diets per unit weight gain. The minimum mean Packed Cell Volume (PCV) of 21% in this study was observed for animals on the 50BA:50GNH diet. Mean Faecal Egg Counts (FEC) showed significant (p<0.05; Table 3) declines at the end of the study but there were no dietary treatment effects. An apparently higher percentage drop was however observed for animals on the 50MO:50GNH diet. Similarly, the parasite recovery data after slaughter did not reflect any significant (p>0.05; Table 4) diet effect and a mixed gastro-intestinal nematode infestation pattern was observed. Worms were present in two (abomasum and large intestine) of the three organs investigated for all the experimental animals while no worms were seen in the small intestine (Table 4).

Table 4: Mean worm burdens in the gastrointestinal tracts of sacrificed WAD goats WAD goats naturally infested with gastrointestinal nematodes previously fed a sole diet of groundnut hay and its combinations with moringa and bamboo leaves

Locations	Diet: 50MOR: 50GNH	50BAM: 50GNH	100% GNH	SEM
Abomasum	234^a	100^c	13^b	32.2
Small intestine	0	0	0	0.0
Large intestine	17^a	300^c	563^b	293.3

^{abc}Means in the same row with different superscripts are significantly (p<0.05) different. MO = Moringa foliage; BA = Bamboo foliage; GNH = Groundnut Hay; BW = Body Weight; SEM = Standard Error of the Mean

The carcass characteristics of the experimental animals are as shown in Table 5. MO substitution of GNH significantly (p<0.05) increased two economically important carcass parameters to the livestock farmer (Warm Carcass Weight [WCW] and Dressing Percentage

Table 5: Mean carcass characteristics of West African Dwarf goats WAD goats naturally infested with gastrointestinal nematodes previously fed a sole diet of groundnut hay and its combinations with moringa and bamboo leaves

	Diet			
Carcass trait	50MOR: 50GNH	50BAM: 50GNH	100% GNH	SEM
Slaughter body weight (kg)	10.90[a]	9.60[b]	10.90[a]	0.30
Warm carcass weight (kg)	5.20[a]	3.50[b]	4.40[b]	0.20
Cold carcass weight (kg)	5.10[a]	3.30[b]	4.20[b]	0.20
Liver weight (g)	210.60[a]	124.90[b]	161.00[b]	12.70
Heart weight (g)	57.50[a]	42.50[a]	52.90[a]	2.80
Kidney weight (g)	70.20[a]	35.60[c]	45.60[b]	3.90
Kidney fat weight (g)	31.60[a]	5.40[c]	13.00[b]	3.10
Blood volume (ml)	372.40[a]	345.00[a]	322.00[a]	11.10
Skin+Head+Feet (kg)	1.80[a]	1.50[a]	1.60[a]	0.10
Percentage shrinkage (%)	1.60[a]	4.90[a]	4.20[a]	1.50
Dressing Percentage (%)	47.30[a]	36.70[c]	40.50[b]	1.20

[abc]Means in the same row with different superscripts are significantly ($p<0.05$) different. MO = Moringa foliage; BA = Bamboo foliage; GNH = Groundnut Hay; BW = Body Weight; SEM = Standard Error of the Mean

[DP]) while BA substitution significantly ($p<0.05$) decreased DP alongside a decrease in WCW, though not statistically ($p>0.05$) significant. Dietary treatments had no significant ($p>0.05$) effects on Percentage Shrinkage (PS), ranging from 1.6-4.9% for 50MO:50GNH and 50B:50GNH diets, respectively. The weights of the heart, skin, head and feet as well as blood volume were not significantly ($p>0.05$) affected by dietary treatments.

The mean CP concentrations of the three experimental feedstuffs were observed to be higher than the minimum of 8% necessary to provide the minimum NH_3 levels required by rumen microorganisms to support optimum rumen activity (Norton, 2003). The nutrient and mineral compositions of the experimental feed components/diet compositions have been extensively discussed by Asaolu *et al*. (2010b). Groundnut hay, with or without moringa or bamboo substitution was observed by the researchers to result in a positive nitrogen balance for WAD goats. Nitrogen intake and retention were also reported to be enhanced by both substitutions. The total phenol of the moringa leaves (3.0% DM) was within the range of 2.7-3.4% reported in earlier works (Gupta *et al*., 1989; Foidl *et al*., 2001) with moringa. At these concentrations these simple phenols do not produce any adverse effect when eaten by animals (Foidl *et al*., 2001). The total tannins levels (moringa, 0.9% DM; bamboo, 0.1% DM; Table 2) were considerably <the 2.1% reported in *Gliricidia sepium* (Ahn *et al*., 1989) as well as the 3-14% reported for *Leucaena leucocephala* D'Mello and Fraser (1981). The total tannins obtained in this study can be described as negligible (Foidl *et al*., 2001) with the condensed tannins level being of no nutritional significance.

Dry matter intake values which ranged from 300-320 g/animal/d for 100GNH and 50MO:50GNH, respectively were similar to the range of 290-316 g/animal/day reported by Asaolu *et al*. (2010b) in a trial with WAD goats assessing the intake, nitrogen utilization and *in vivo* nutrient digestibility of moringa and bamboo leaves in equal combinations, respectively with groundnut hay.

When ruminants are offered roughages such as hay and dried grass, there is evidence (Allison, 1985) that they eat to a constant rumen fill; a probable reason for the observed non-significant differences in DMI, as at least 50% of their respective diets was hay (GNH). The observed Average Daily Gain (ADG) values ranging from 6.8 (50BA:50GNH) to 17.0 g/animal/day (50M:50GNH) were however lower than the post-weaning growth rate of 36.4 g/animal/day reported by Dhollander *et al*. (2005) for some intensively-managed WAD goats in The Gambia. The reduced growth rates in this study reflected the gastro-intestinal nematode challenge that the animals were subjected to, coupled with the fact that the animals used by Dhollander *et al*. (2005) were strategically treated for gastro-intestinal nematode infection as described by Kaufmann (1996). The observed values for FCR supported the earlier observed improvement of the overall nutrient utilization of GNH by MO substitution by WAD goats (Asaolu *et al*., 2010b).

The mean PCV of all the experimental animals fell within the range of 21-35% reported for WAD goats (Dhollander *et al*., 2005; Ikhimoya and Imasuen, 2007). Dhollander *et al*. (2005) reported PCV values above 20% during the whole year for WAD goats and their Saanen crosses in a zero-grazing farming system in The Gambia, with minimum PCVs being observed during the rainy season in November in the crosses (23%) and in October in WAD goats (21%). The final mean nematode faecal egg counts of 334, 369 and 384 eggs/g of faeces/animal for 50MO:GNH, 50BA:GNH and 100% GNH, respectively were in the low to medium category as per the classification method adopted by Kouch *et al*. (2005).

The observed non-significant ($p>0.05$) dietary effects on parasite recovery data after slaughter, along with the observed non-dietary treatment effects ($p>0.05$) on faecal egg counts across experimental treatments (Table 3) indicate that the level of condensed tannins in moringa (0.1%DM; Table 2) was too low to have any effects, direct or indirect, on gastro-intestinal parasites. Condensed tannins are reportedly (Barry and Manley, 1984) beneficial to ruminants at moderate levels (2.0-4.0% DM) without deleterious effects on animal performance. The presence of worms in the abomasums of all the sacrificed animals suggests the prevalence of *Haemonchus contortus*, the nematode of particular concern worldwide, especially in tropical and subtropical climatic regions (Hansen and Perry, 1994) in the study area. Reyes (2006) in a study with sheep found only *Haemonchus contortus* in the abomasum. Nematodes that are common in the abomasum are *Haemonchus contortus* (Barber pole worm) and *Telodorsagia circumcincta* (Brown stomach worm) while the common nematode in the large intestine is *Oesophagostumum* spp. (Nodular worm) (Miller and Horohov, 2006).

To meat processors, wholesalers and producers to some extent, the value of the carcass lies in its potential saleable meat yield (Chrystall, 1998) as indicated by the WCW and DP. Literature reports (Dhanda *et al*., 1999; Getahun, 2001) indicate that DP in goats varies between 38 and 56%. The observed higher values for carcass components of the animals on MO-substituted diet could possibly be attributed to the quality of the crude protein of moringa foliage rather than the condensed tannins content. The crude protein of moringa is of better quality for ruminants than the crude protein of most forages such as gliricidia and leucaena because of its high content of bypass protein, 47 versus 30 and 41%, respectively (Becker, 1995). Chilling losses ranging from 2.3-8.7% have been reported for different goat genotypes and weights (El Khidir *et al*., 1998; Getahun, 2001). Low percentage shrinkage values have been attributed (Sebsibe *et al*., 2007) to lower rib chemical fats content and lean: fat ratios of the primal cuts, although, these parameters were not measured in this study. The non-significant (p>0.05) dietary effects on the weights of the heart, skin, head and feet as well as blood volume (Table 5) were similar to the observations of Okello *et al*. (1996) with Mubende goats fed a basal diet of *Pennisetum purpureum* along with some agro-industrial by-products as supplements.

CONCLUSION

There were no condensed tannins of nutritional or anthelmintic significance in both moringa and bamboo leaves. The threat of gastrointestinal nematodes to the productivity of goats in the study area, as in other tropical and sub-tropical regions of the world was further confirmed. However, complementing groundnut hay which is the traditional feed resource of choice in The Gambia, with moringa foliage (50:50 ratio), appears to be a viable option to improving the nutritional status and important carcass components of gastrointestinal nematode-infested goats. Although this feeding strategy did not assist the host animals to regulate nematode populations, it assisted them to withstand the negative effects of nematode infestations in addition to obtaining relative positive effects on animal productivity under the parasitic challenge.

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