ISSN:
Print - 2277 - 0755
Online - 2315 - 7453

Journal of Agricultural Science and Environment

EFFECT OF ANTI-NUTRITIONAL FACTORS ON RUMEN BACTERIA OF WEST AFRICAN DWARF GOATS FED TROPICAL BROWSE SPECIES AND CROP BY-PRODUCTS

O.A ISAH*, R.Y. ADERINBOYE AND V.A. ENOGIERU

Department of Animal Nutrition, Federal University of Agriculture, Abeokuta, Ogun State, Postcode 110001. Nigeria.
***Corresponding author**: bukolaisah@yahoo.com **Tel:** +2348138436385

ABSTRACT

In this study, the effects of anti-nutritional factors on rumen bacteria of West African Dwarf (WAD) goats fed tropical browse species and crop by-products were investigated. In a completely randomized design, 36 WAD goats were allotted to six (6) supplemental diets (*Gmelina arborea, Enterolobium cyclocarpum, Albizia saman,* Maize offal, Cassava peels and Palm kernel cake), with six replicates per treatment. Animals were fed for 84 days with *Panicum maximum* as basal diet. Results revealed the presence of anti-nutritional components in supplemental browse species and crop residues. Hydro-cyanide was highest ($P<0.05$) in cassava peels while tannin content was highest ($P<0.05$) in the browse species relative to the crop residues. Results also showed reduction in microbial population in goats fed *Gmelina arborea, Enterolobium cyclocarpum, Albizia saman,* Cassava peels and Palm kernel cake. Goats on maize offal supplemented diet showed increases in microbial population. Adverse effects of anti-nutritional content in feeds fed to animals were not detected in terms of intake and weight gain performances. The reduction in microbial population in the rumen, however, indicates possibilities of bactericidal effect with feeding diets containing anti-nutritional components.

Keywords: Goats, Anti- nutritional factors, Rumen bacteria

INTRODUCTION

Goat is small ruminant that can select their diet from a broader array of plant species. This special ability of theirs may be achieved through their special feeding behaviour, enabling them to select proper diet and to obtain nutrients for meeting their requirements for maintenance and production. Due to its special feeding behavioural characteristics and metabolic efficiency, goats are able to use and convert low quality forages into useful products (Jakhesara *et al.*, 2010). The efficiency of ruminants to utilize such a wide variety of feeds is due to highly diversified rumen microbial ecosystem consisting of bacteria (10^{10}–10^{11} cells/ml, representing more than 50 genera), ciliate protozoa (10^4–10^6/ml, from 25 genera), anaerobic fungi (10^3–10^5 zoospores/ml, representing five genera) and bacteriophages (10^8–10^9/ml) (Kamra, 2005). Without ruminal microorganisms, or when the ruminal ecosystem is disturbed, there can be cascade of detrimental effects on animal health and productivity. Small-scale farmers are increasingly relying on browse and on crop residues and by-products to supplement roadside grazing during the dry season (Smith *et al.*, 1991). In some extensive ruminant production systems, browse plants may represent an important source of nutrients to grazing animals. Several non-conventional feed resources such as crop by-products and browse species are known to contain some anti-nutritional factors (ANFs), which could affect the activities of microbes in the rumen and consequently, the eventual utilization of feeds by ruminants (Onwuka, 1991; Ologhobo, 1989). Many of these plants contain relatively high levels of condensed tannins, and other naturally occurring compounds. Therefore, whether by choice or necessity, herbivores consume tannins and these secondary compounds can have detrimental or beneficial effects on animal nutrition (Min *et al*., 2003). There are indications that some of these ANFs have defaunation qualities while some have bactericidial, or bacteriostatic properties and have been used to treat one ailment or the other (Osuji *et al*., 1995). Although a variety of non-conventional feeds are traditionally used in livestock feeding, little or no information is known about the presence of ANFs and their effect on the rumen environment and microbial activity. The study therefore aims at evaluating the effect of some ANFs on rumen characteristics and bacteria profile of WAD goats fed some tropical browse species, and by-products.

MATERIALS AND METHODS

The experiment was conducted during the month of October to December at the goat unit of the College of Animal Science and Livestock Production (COLANIM) farm, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria. The site is situated in the rainforest vegetation of South Western Nigeria with annual mean temperature of 34.7^{0}C and a relative humidity of 82%. It falls within latitude 7^{0}5 - 7^{0}8'N and longitude 3^{0}11.2' - 3^{0}23.5'E. A total of 36 WAD goats having ages between 8 and 12 months with an average weight of 6.53 ± 0.35 were used for the experiment. On arrival at the farm, animals were de-wormed with albendazole to check against endoparasites and dipped in Asuntol solution against ectoparasites. Initial weights of the animals were taken. Animals were thereafter divided into six (6) groups of six animals each. Each group of animals was allotted to one of six (6) supplemental diets consisting of *Albizia saman, Enterolobium cyclocarpum, Gmelina arborea* (as browses) and maize offal, palm kernel cake, dried cassava peels (as crop by products) in a completely randomized design. *Panicum maximum* was fed as the basal diet to all groups. Animals were housed individually in disinfected and well ventilated pens and were supplied with clean water *ad libitum*. Experimental diets (500g) and water were offered daily at 7.00 a. m. while *Panicum maximum* was made available *ad libitum* at 10.00 a. m. for a period of 84 days. During this period, left over of feeds was weighed and discarded the following morning. Rumen fluid was collected from the animals at the beginning and at the end of the experiment and analyzed (Figures 1, 2 and 3) to identify the bacteria present in the rumen and the level at which they are present (Galyean, 1989, Hobson, 1965, Hungate, 1969). The Proximate (AOAC, 2000) and the anti-nutritional content (Youngs, 1936) in the experimental diets were also determined. All data generated were analyzed using the analysis of variance (SAS 1999). Significant means were separated using the Duncan multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

In Table 2, tannin contents were observed to be higher in the browse species compared to the crop by products, ranging between 0.046

Figure. 1: Cultured organisms on a nutrient agar

Figure 2: Bacteria growth on plates in a glass jar after 24hours of incubation

Figure 3: Bacteria growth on plates after 24hours of incubation

Table 1: Proximate Composition (%) of the Experimental Diets

Compo-sition*	Cassava peels	Palm kernel cake	Maize offal	G. arborea	E. cyclo-carpum	A. saman	SEM
DM	91.20^{a}	90.56^{a}	86.53^{a}	39.04^{b}	32.15^{b}	34.05^{b}	12.40
CP	5.20^{d}	16.50^{ab}	12.25c	15.05^{b}	17.07^{a}	16.19^{ab}	1.84
CF	15.80^{a}	10.33^{b}	14.94^{a}	10.46^{b}	8.16^{c}	11.00^{b}	1.21
EE	1.50^{d}	11.25^{a}	5.39^{b}	1.04e	2.21^{d}	4.00c	1.56
ASH	1.50^{d}	5.75^{b}	4.97^{c}	8.96^{a}	7.85^{a}	$5.00b^{c}$	1.06
NFE	76.00^{a}	56.09^{d}	62.45^{bc}	64.49^{b}	64.71^{b}	61.81^{c}	2.67

^{a,b,c,d,e} Means along same row with different superscripts are significantly different (P<0.05)
*DM = Dry Matter (as fed), CP = Crude Protein, CF = Crude fibre, EE =Ether extract, NFE = Neutral Detergent fibre.
SEM: Standard error of mean

Table 2: Anti-nutritional Component (%) of Experimental Diets

Composition	Cassava peels	Palm kernel cake	Maize offal	G. arborea	E. cyclocarpum	A.saman	SEM
Tannin	0.024^{c}	0.019^{c}	0.024^{c}	0.064^{a}	0.076^{a}	0.046^{b}	0.001
Saponin	0.198^{c}	0.295^{ab}	0.213^{b}	0.232^{b}	0.305^{a}	0.247^{ab}	0.019
Oxalate	0.500^{b}	0.428^{cd}	0.398^{d}	0.581^{cb}	0.679^{a}	0.495^{bc}	0.043
Phytate	0.263^{d}	0.385^{b}	0.225^{e}	0.326^{c}	0.496^{a}	0.362^{b}	0.039
HCN	0.501^{a}	0.051^{b}	0.011^{d}	0.025^{c}	0.021^{c}	0.019^{c}	0.008

^{a,b,c,d,e} Means along same row with different superscripts are significantly different (P<0.05)
SEM: Standard error of mean

Table 3: Rumen Bacterial Count in West African Dwarf Goats fed Experimental Diets

Bacteria count (x106cfu/ml)	Cassava peels	Palm kernel cake	Maize offal	G. arborea	E. cyclocarpum	A. saman	SEM
Before feeding	7^{c}	12^{ab}	13^{a}	11^{b}	6^{c}	13^{a}	0.017
After feeding	5^{cd}	5^{cd}	17^{a}	10^{b}	4^{d}	6^{c}	0.017

A,b,c,d Means along same error with different superscripts are significantly different (p<0.05)
SEM: Standard error of mean

Table 4: Bacteria identified in the rumen fluid of West African Dwarf goats fed Experimental Diets

Isolates	C Peel	PKC	M offal	G. aborae	E. cyclo	A. sama
Proteus spp.	-	++	+++	-	-	+
Lactobacillus spp.	-	+	+++	+	+	-
Peptococcus spp.	+	-	++	++	++	-
Streptococcus spp	++	+	++	+	+	++

C peel = cassava peels, PKC = palm kernel cake, M offal = maize offal, G. arborea = *Gmelina arborea*, E. cyclo = *Enterolobium cyclocarpum*, A. sama = *Albizia saman* +++ = high, ++ = medium, + = low, - = not present

Table 5: Intake and weight gain (g/day) of WAD goats fed experimental diets

Parameters	Cassava peels	Palm kernel cake	Maize offal	G. arborea	E. cyclocarpum	A. sama	SEM
Average DMI (g/d) from:							
P. maximum (basal diet)	113.71[d]	112.86[d]	106.86[d]	146.57[b]	164.86[a]	137.14[c]	0.001
Feed supplement	101.91[a]	95.71[ab]	88.86[b]	94.86[ab]	109.43[a]	87.14[b]	
Total DMI (g/d)	215.62[bc]	208.57[c]	195.72c	241.43[ab]	274.29[a]	224.28[b]	
Average daily weight gain (g/d)	29.14[ac]	24.29[d]	32.86[b]	28.57[c]	39.05[a]	31.43[b]	

[a,b,c,d] Means along same row with different superscripts are significantly different(P<0.05)
DMI: dry matter intake
SEM: Standard error of mean

and 0.064% for browses and between 0.019 and 0.024% for crop by products. Saponin was found to be lowest in cassava peels (0.198%) and highest in *E. cyclocarpum* (0.305%). Oxalate was found to be highest in *Enterolobium cyclocarpum* having 0.679%. *Gmelina arborea* had 0.581% while *Albizia saman* had 0.495%. For crop by-products, oxalate was highest in cassava peels (0.50%) and lowest in maize offal (0.398%). Phytate was lowest in maize offal (0.225%) and highest in *Enterolobium cyclocarpum* (0.496%). Palm kernel cake had 0.385% and it was followed by *Albizia saman* (0.362%) and *Gmelina arborea* (0.326%). Cassava peels had phytate content of 0.263%. Hydrocyanide was highest in cassava peels (0.501%), palm kernel cake had 0.051% HCN, and maize offal had a value of 0.011%. Browse species gave values of 0.025% for *Gmelina arborea*, 0.021% for *Enterolobium cyclocarpum*, and 0.019% for *Albizia saman*.

Table 3 shows that bacteria load was affected by the presence of anti-nutritional factors in feed. Animals fed cassava peels had initial bacterial count of $7x10^6$cfu/ml which reduced to $5x10^6$cfu/ml due probably to the presence of hydrocyanide. Those fed palm kernel cake had initial count of $12x10^6$cfu/ml which was reduced to $5x10^6$cfu/ml. Animals fed maize offal had an increase in bacterial load from $13x10^6$cfu/ml to $17x10^6$cfu/ml. This increase in microbial load with maize offal might probably be due to the low amount of ANFs present in the feed supplement which might be as a result of series of processing which maize had gone through relative to other crop by products. Animals fed *Gmelina arborea* had a slight reduction in bacterial load from $11x10^6$cfu/ml to $10x10^6$cfu/ml. Though tannin, saponin and oxalate were fairly high compared to others in the groups, the ether extract was low, while fibre was high; this might account for the low reduction in bacterial count compared to the drastic reduction in animals fed palm kernel cake which had high ether extract and low crude fibre. Animals fed *Enterolobium cyclocarpum* had reduction in bacterial count from $6x10^6$cfu/ml to $4x10^6$cfu/ml. Similarly, those fed *Albizia saman* had a reduction from $13x10^6$cfu/ml to $6x10^6$cfu/ml, indicating that the anti-nutritional factors in these feeds affected bacteria population. Table 4 shows the bacteria identified in the rumen of animals fed these different feed supplements. *Proteus species* was low in animals fed *Albizia saman*; absent in *Enterolobium cyclocarpum*, *Gmelina arborea* and cassava peels probably due to high presence of ANFs as shown in Table 2. It was however high in animals fed maize offal and palm kernel cake which might be due to the high availability of degradable crude protein made possible through processing. *Lactobacillus species* was absent in animals fed *Albizia saman*, low in those fed *Enterolobium cyclocarpum*, *Gmelina arborea* and palm kernel cake. However, it was high in those fed maize offal probably because it contains soluble carbohydrates (Hussein, 1991). *Peptococcus species* was absent in animals fed *Albizia saman* and palm kernel cake, probably due to similar phytate content, high in those fed *Enterolobium cyclocarpum*, *Gmelina arborea* and maize offal and medium in those fed cassava peels. *Streptococcus spp* was present in all, since it digested sugar, protein and fats (Church, 1988), but was low in the rumen of animals fed *Enterolobium cyclocarpum*, *Gmelina arborea* and palm kernel cake and medium in animals fed *Albizia saman*, maize offal and cassava peels.

The non-identification of more specific fibre degrading microbes such as *Fibrobacter succinogens*, *Ruminococcus* spp, Butyrivibrio fibrisolvens and *Bacteriodes succinogenes* could not be explained. Tannins have been reported to be most effective against the fibre-degrading (cellulolytic) bacteria like *Fibrobacter succinogens, Ruminococcus* spp. (McSweeney *et al*., 1999), *Butyrivibrio fibrisolvens* (Jones *et al*., 1994). This was not however, confirmed in this study. The main limitation to the use of browse species as animal feed is the presence of anti-nutritional factors, though they are good source of protein for range animals (NRC, 1995, D'Mello, 1992). Crop by-products are also shown from the study to contain these inhibitory factors. From the study, anti-nutritional factors present in these browse spp. and crop by-products might have defaunation qualities since they affect the bacteria population in the rumen. Bacterial count in the rumen content, which reflects the population of microbes in rumen, was found to reduce after feeding goats on both browse species and crop by-products, except in maize offal which slightly increased. Microbes have been reported to survive in the rumen under different constraints which may be either natural or feed associated as some of the feeds contain a significant amount of anti-nutritional factors, which sometimes limit the growth of some of these natural microbial inhabitants (Kamra, 2005). Feed intake in goats fed crop residues and browse species was between 196 and 216 g/d and between 224 and 274 g/d, respectively while weight gain was between 24 and 33 g/d and between 29 and 39 g/d for crop by products and browse species, respectively (Table 5). The quantity of anti-nutrients present in these feedstuffs was not considered as detrimental to the animals in terms of feed intake and weight gain performances. Averages were comparable with reported intake and weight gain values for goats (NRC, 1981). Harmful and beneficial nutritional effects of anti-nutritional factors have been reported (Osakwe, 1999). Polyphenols may complex with proteins during ingestion and digestion in the ruminant and affect degradation enzymes in the rumen (Makkar *et al*., 1988). However, tannin helps to reduce wasteful protein degradation in the rumen by the formation of protein- tannin complex in the rumen but the protein is made available later in the lower gut.

Though browse species and crop by-products are useful in providing animals with feed during the dry season, attempt should be made to process them thoroughly before use to reduce their negative effect on rumen bacteria.

REFERENCES

A.O.A.C. 2000. Official methods of analysis, 17th ed. *Association of Official Analytical Chemists*. Arlington, VA.

Church, D.C. 1988. *The Ruminant Animal: Digestive Physiology and Nutrition*. Englewood Cliffs, N.J., Prentice Hall.

D'Mello, J.P.F. 1992 Chemical constraints to the use of tropical legumes in Animal Nutrition. *Anim. Feed Sci. Technol*., 38: 237-261

Galyean, M. 1989. *Laboratory Procedure in Animal Nutrition Research*. Department of Animal and life Science. New Mexico State University, USA.

Hobson, P.N. 1965. Continuous culture of some anaerobic and facultative anaerobic rumen bacteria. *J. Gen. Microbiol.,* 105: 770-777.

Hungate R.E. 1969. *The rumen microbial ecosystem*. Annual review of Ecology and systematic 6: 39-66 Linnaeus 1758: Binomial nomenclature of Animals. 6:39-66.

Hussein, H.S., Stern, M.D., Jordan, R.M. 1991. Influence of dietary protein and carbohydrate sources on nitrogen metabolism and carbohydrate fermentation by ruminal microbes in continuous culture. *J. Anim. Sci.,* 69: 21-23.

Jakhesara, S.J., Koringa, P.G., Ramani, U.V., Ahir, V.B., Tripathi, A.K., Soni, P.S., Singh, K.M., Bhatt, V.D., Patel, J.S., Patel, M.M., Sajnani, M.R., Joshi, C.G. 2010. Comparative study of tannin challenged rumen microbiome in goat using high throughput sequencing technology. *Developmental Microbiology and Molecular Biology*, 1 (1): 95 – 106.

Jones, J.A., McAllister, T.A., Muir, A. D., Cheng, K. J. 1994. Effects of sanfoin (*Onobrychis vicifolia Scop*.) condensed tannins on growth and proteolysis by four strains of ruminal bacteria. *Appl. Environ. Microbiol*, 60: 1374–1378.

Kama, D.N. 2005. Rumen microbial ecosystem. Special section, Microbial diversity. *Current Science*, 89(1): 124 - 139.

Makkar, H.P.S., Dawra, R.K., Singh, B. 1988. Determination of both tannin and protein in a Tannin-protein complex. *J. Agric. Food Chem.,* 36: 523-525.

McSweeney, C.S., Palmer, B., Krause, D.O., Brooker, J.D. 1999. Rumen microbial ecology and physiology in sheep and goats fed a tannin containing diet. *Proc. International Workshop,* Adelaide, Australia, 31 May – 2 June, 1999, p. 140–145.

Min, B.R., Barry, T.N., Attwood, G.T., McNabb, W.C. 2003. The effect of condensed tannins on the nutrition and health of ruminants fed fresh temperate forages: a review. *Anim. Feed Sci. Technol*., 106: 3–19.

NRC. 1981. Nutrients Requirements of Goats. *National Research Council*. National Academy Press, Washington, DC.

NRC 1995. Effects of polyphenolic compounds in forage from multipurpose folder trees on growth, intake and digestion in sheep and goats. *National Research Council.* Annual report, 1995

Ologhobo, A.D. 1989. Mineral and antinutritional content of forage legumes consumed by goats in Nigeria. *African small ruminant research Network, ILCA, Addis Ababa Ethiopia,* p. 219-229

Onwuka C.F.I 1991. Browse tannins and saponin influence on performance of WAD goats. *Proc., 16th Annual Conference of Nigerian Society of Animal Production. (NSAP)* held at Usmanu Dan Fodiyo University, Sokoto

Osakwe, I. 1999. The effect of selected tannin containing browse plants on energy metabolism and digestion parameters of West African dwarf Sheep. *Verlag Grauer, Stuttgart*, p 3-15

Osuji, P.D., Fernandez-Rivera, S., Odenyo, A. 1995. Improving fibre utilization and protein supply in animals fed poor quality roughages In: ILRI Nutrition Research and Plans. In: Wallace, R.J. and Lahlou-Kassi, A. (eds.). Rumen Ecology Research Planning. *Proceedings of a workshop held at ILRI, (International Livestock Research Institute) Addis Ababa, Ethiopia*. 13-18 March, 1995.PI.

SAS 1999. SAS/STAT. *User`s Guide*. Version 8.0 SAS Institute inc., Carry, North Carolina, USA..

Smith, O.B., Idowu, O.A., Asaolu, V. O., Odunlami, O. 1991. Comparative rumen degradability of forages, browse, crop residues and agricultural by-products. *Livest. Research for Rural Development.* 3(2): http://www.lrrd.org/lrrd3/2/smith.htm

Young, V. 1936 Determination of phytic acid. *Biochem. J.,* 30: 252.

(Manuscript received: 1st March, 2011; accepted: 24th June, 2011).