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Effect of different tropical roughages on nutrient digestibility and rumen fermentation parameters of West African Dwarf sheep during dry season

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ABSTRACT

This experiment was designed to determine the effect of selected tropical roughages on digestibility and rumen parameters of West African dwarf sheep. West African dwarf female sheep (24) weighing 12.2 ±0.26 kg, were allocated to 4 treatments in a completely randomized design. The experimental animals were fed on *Panicum maximum* hay (PAHA, T_1), 5% urea-treated corn cob (UTCC, T_2), 5% urea-treated sugarcane top (UTST, T_3) and cassava hay (CAHA, T_4). Results showed highest dry matter (DM) intake (575.74 g/day) in sheep fed on UTST while DM intake was lowest in those fed on UTCC (377.04 g/day). Dry matter, neutral detergent fibre and acid detergent fibre digestibilities were highest in sheep fed on UTST while crude protein digestibility was highest in animals fed on CAHA. Rumen NH_3-N and blood urea nitrogen (BUN) concentrations were high in animals fed on CAHA. Total VFA (116.00 mM), acetate (70.85 mol/100ml) and propionate (23.40 mol/100ml) concentrations were highest in sheep fed on PAHA. Protozoa, fungal and total viable bacteria counts were different across the treatments. This study revealed that UTST, PAHA and CAHA could be utilized for productive purposes while UTCC could serve as a maintenance ration for West African dwarf sheep during the long period of dry season when grasses are not available.

Key words: Intake, Microbial population, Nutrient digestibility, Rumen fermentation, Tropical roughages, West African dwarf sheep

Poor quality of feed materials during dry season is a major challenge for the ruminant animal production in the tropics (Oluwatomi 2010). Feeding of such low quality forages affect the intake and digestibility by animals adversely and thereby reduce performance. The ever increasing human population and demand for animal origin food have made conventional livestock foodstuffs to be very scarce and costly. The search for cheap alternative foodstuffs such as crop residues and byproducts of food industry become necessary to fulfil the requirement of large human populations through livestock (Jayasuriya 2010). High fibre and low nitrogen contents are some of the nutritional constraints for crop residues as animal feedstuffs. Crop residues such as sugarcane tops, cassava leaves and corn cobs are available in large quantity in Nigeria and treatment with urea improved the nutritive value of some of these crop residues (Wanapat 1999). If all the available crop residues are judiciously utilized as a source of fodder for ruminants, problem of feed shortage during dry season will be greatly reduced. This experiment is therefore designed to compare the effects of different tropical roughages (*Panicum* hay, urea-treated corn cobs, urea-treated sugarcane tops and cassava hay) on nutrient digestibility and fermentation parameters of West African dwarf sheep.

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MATERIALS AND METHODS

Feed management: Crushed corn cobs and chopped sugarcane top (2 to 4 cm) were treated with 5% urea (w/w). Pholsen *et al.* (1996) and Wora-anu *et al.* (2007) treated sugarcane top and rice straw with 6% and 5% urea, respectively, without any negative effect. Urea treatment was done by dissolving 0.5 kg urea in 10 litre of water and poured on corn cobs and sugarcane tops separately. Thereafter, treated materials were covered with plastic sheet for 10 days before feeding to animals. The temperature and humidity range during the experiment were 26°–33°C and 62–65% respectively.

Cassava (Odongbo variety) leaves including stalks were chopped into small pieces (about 2 to 4 cm) and sun-dried for 2 to 3 days until the dry matter content reached 85% to obtain cassava hay (Fasae *et al.* 2011).

Fresh *Panicum* leaves were harvested before flowering stage and chopped into small pieces (6–8 cm), allowed to sundry with regular turning for about 7 days. Chemical analysis of panicum hay (PAHA), urea-treated corn cob (UTCC), urea-treated sugarcane top (UTST) and cassava

Table 1. Chemical composition of concentrate, *Panicum* hay, urea treated corn cob, urea treated sugarcane top and cassava hay

Ingredients (%)	Concentrate	PAHA	UTCC	UTST	CAHA
Maize	10.00	-	-	-	-
Palm kernel cake	25.00	-	-	-	-
Wheat offal	55.00	-	-	-	-
Bone meal	8.00	-	-	-	-
Premix	1.00	-	-	-	-
Salt	1.00	-	-	-	-
Total	100.00	-	-	-	-
Chemical composition					
DM (%)	89.32	82.20	80.15	80.50	85.70
		% of DM			
OM	97.83	87.84	95.36	84.75	91.70
CP	14.7	6.17	9.80	10.73	20.10
Ash	2.17	12.16	4.64	15.25	8.30
NDF	29.30	68.76	80.00	70.52	59.40
ADF	22.00	39.86	39.00	37.20	35.60
Condensed tannin (g/kgDM)	-	-	-	-	39.00

hay (CAHA) was carried out and chemical composition is shown in Table 1.

Digestibility and rumen fermentation studies: Female West African dwarf (WAD) sheep (24) with average weight of 12.2 kg were randomly assigned to 4 experimental treatments having 6 replicates in each in a completely randomized design. The animals were housed individually in disinfected and well ventilated pens. All animals were offered concentrate feed at 2% of body weight daily, while the experimental foodstuffs (PAHA, UTCC, UTST and CAHA) were offered *ad lib*. During this period, voluntary feed intake and left over were weighed.

Digestibility trial was lasted for 14 days and 3 animals per treatment were used for determining the digestibility of different diets. Feed intake was measured and during the last 7 days, faeces voided were also recorded.

Faecal and feeds samples were analysed for dry matter (DM), crude protein (CP), ether extract (EE) and ash content (AOAC 1990). However, neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined using Van Soest *et al*. (1991) procedures. Condensed tannin content was analyzed in cassava hay according to Burns (1971).

In the end of digestibility trial, rumen fluid was collected from each animal at 0 and 4h post-feeding via the oesophagus through the use of suction tube for fermentative and microbial analyses. About 60 ml of rumen fluid was collected from each animal and sub-fractioned into two sets for ammonia and VFA analysis using AOAC (1990) and Samuel *et al*. (1997) methodology, respectively. pH and temperature were measured immediately. The second sub-portion was fixed with 10% formalin solution in a sterilized 0.9% saline solution for the enumeration of total bacteria, protozoa and fungal zoospore as per the method of Baker and Breech (1986).

Blood sample (5 ml) was also collected from the jugular veins of experimental animals kept under digestibility trial and plasma was separated by centrifugation at 500 × *g* for 10 min and stored at –20°C till plasma urea nitrogen analysis was carried out according to the method of Crocker (1967).

Statistical analysis: All data collected were subjected to one-way analysis of variance using generalized linear model procedure (SAS I999). Data were analysed using the model $Y_{ij} = \mu + T_i + \Sigma_{ij}$ where Y_{ij} is observation from animal j receiving diet i, μ, population mean; T_i, effect of type of roughage source (i = 1, 2, 3, 4); Σ_{ij}, residual error. Treatment means were statistically compared using Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

Intake and digestibility: Crude protein content of treated feeds in present study was lower than the values reported by Megahed and Etman (2006) treated sugarcane top and corn cob with 1% urea. The protein content of CAHA was almost similar to the values reported by Fasae *et al*.(2011). Variation observed might be due to differences in geographical location, age of plant and time of harvesting (Isah *et al.* 2012)

Table 2. Effects of different tropical roughages on feed intake, apparent digestibility and weight changes of West African dwarf sheep

Parameters	Treatments				
	PAHA	UTCC	UTST	CAHA	SEM
Total dry matter intake(g/day)	606.45^{b}	377.04^{d}	575.74^{b}	518.31^{c}	26.69
Total dry matter intake(g/kgW$^{0.75}$)	87.87^{a}	56.68^{d}	81.69^{b}	74.83^{b}	3.54
Initial weight (kg)	12.30	12.13	12.18	12.28	0.08
Final weight (kg)	14.32^{ab}	13.03^{b}	15.38^{a}	14.52^{a}	0.26
Total weight gain(kg)	2.02^{b}	0.90^{c}	3.20^{a}	2.24^{b}	0.23
Apparent digestibilities (%)					
Dry matter (DM)	69.90^{a}	55.68^{b}	70.26^{a}	67.77^{a}.	1.08
Organic matter (OM)	68.00	70.44	74.16	69.30	1.03
Crude protein (CP)	70.55^{b}	67.78^{b}	78.93^{a}	79.36^{a}	1.75
Neutral detergent fibre (NDF)	70.08^{b}	70.73^{b}	76.36^{a}	65.45^{b}	1.36
Acid detergent fibre (ADF)	55.74^{ab}	50.92^{b}	62.23^{a}	50.28^{b}	1.85

Table 3. pH, temperature, ammonia nitrogen, plasma urea nitrogen, ruminal fatty acids production and rumen microbial population of WAD sheep fed different tropical roughages

Parameters	Treatments				
	PAHA	UTCC	UTST	CAHA	SEM
pH	6.65^{a}	6.71^{b}	6.80^{b}	6.90^{a}	0.05
Temperature (°C)	38.6	38.7	39.1	38.8	0.06
Rumen NH_3-N (mg/dl) 0 h	10.12^{c}	11.45^{b}	12.55^{b}	14.30^{a}	1.22
4 h	12.65^{ab}	11.85^{b}	11.06^{b}	15.42^{a}	1.64
Plasma urea-N(mg/dl) 0 h	7.61^{c}	7.85^{c}	8.72^{b}	9.62^{a}	0.52
4 h	8.80^{b}	7.20^{b}	8.93^{b}	11.24^{a}	0.72
Total VFA (mM)	116.00^{a}	109.25^{ab}	104.10^{b}	95.94^{c}	2.58
Acetate (C_2) mol/100mol	70.85^{a}	70.00^{a}	68.10^{ab}	66.35^{b}	0.67
Propionate (C_3) mol/100mol	23.40^{a}	21.00^{ab}	21.50^{ab}	20.75^{b}	0.4
Butyrate (C_4) mol/100mol)	10.75^{b}	12.15^{b}	12.35^{b}	18.10^{a}	0.91
$C_2 : C_3$ ratio	3.03	3.33	3.18	3.2	0.52
$C_2 + C_4 : C_3$ ratio	3.49^{b}	3.91^{a}	3.75^{ab}	4.07^{a}	0.77
Ruminal microbes (cell/g)					
Bacteria ($\times 10^{12}$)	4.72	4.6	4.27	4.25	2.35
Protozoa ($\times 10^{5}$)	5.53^{a}	6.50^{a}	4.43^{b}	2.28^{c}	0.42
Fungal zoopores ($\times 10^{6}$)	5.20^{b}	6.18^{b}	8.13^{a}	4.30^{c}	0.56
Total viable bacteria ($\times 10^{12}$ CFU/ml)	4.92^{a}	3.75^{b}	4.90^{a}	4.35^{b}	0.15

Data related to feed intake, apparent digestibility and weight changes are given in Table 2. Daily DM Intake (g/kg $W^{0.75}$) was significantly different ($P<0.05$) among the treatments with PAHA having the highest value. Highest dry matter intake in sheep fed on PAHA (87.87g/kg$W^{0.75}$) could be due to the fact that PAHA contained highest DM and relatively low NDF compared to UTCC and UTST. The low dry matter intake in sheep fed on CAHA (74.83g/kg$W^{0.75}$) could be attributed to residual bitter flavour contained in CAHA as a bitter variety of cassava was used in this experiment. Ravindran *et al*. (1987) showed that the bitter taste of cassava foliage could negatively influence the intake by animals. Lowest DM intake observed in sheep fed on UTCC could be as a result of NDF content of UTCC. The nutrient digestibility values obtained in this study might be an indicative of proper utilization of the feedstuff as digestibilities of all nutrients were fairly high in all the treatments. Apparent digestibilities (%) of DM, OM CP, NDF and ADF were significantly different ($P<0.05$) between the treatments. Dry matter digestibility was higher in sheep fed urea-treated sugarcane top (70.26%). The DM digestibility coefficient was higher than that of reported by Kevelenge *et al*. (1983) and the difference may be attributed to urea treatment. High crude protein content of cassava hay played significant role in improving digestibility of protein as crude protein digestibility was highest in sheep fed on cassava hay (77.45%). This result supported McDonald *et al*. (1987) who stated that concentration of crude protein in a feedstuff affect its digestibility. Also, condensed tannin contained in cassava hay (39g/kg DM) might have increased its ruminal by-pass protein potential because cassava hay was reported to contain tannin-protein complexes which could act as rumen by-pass protein and thereby increasing its digestibility in the small intestine (Wanapat 2002). The metabolic weight gain of animals on PAHA, UTST and CAHA were similar ($P>0.05$) while animals on UTCC recorded lower ($P<0.05$) but positive weight gain. This implies that PAHA, UTST and CAHA could be fed to WAD sheep to meet their productive requirement in terms of weight gain whereas UTCC could be used to sustain the animal as maintenance ration during long period of dry season.

Fermentation pattern and microbial enumeration: Rumen temperature was similar across treatments and the values were in the range 38.6 to 39.1°C (Table 3). The ruminal pH was significantly ($P<0.05$) influenced by the treatments with sheep fed CAHA having significantly higher value of 6.90. The pH range (6.7 to 6.9) obtained across treatments were within the normal range (pH 6 to 7) reported as optimal for microbial digestion of fibre (Firkins 1996) and also for digestion of protein in the rumen (Wanapat 1999). The increased ruminal pH in CAHA treatment could have been due to condensed tannin contained in it which stimulate saliva secretion and hence, increasing urea recycling in the rumen (Reed 1995).

Ruminal ammonia-nitrogen and plasma urea-nitrogen concentration were significantly different ($P<0.05$) across treatments at 0 and 4 h of sampling. Increased rumen ammonia-nitrogen level resulted in increased blood urea-nitrogen level across treatments. It was found that plasma-urea nitrogen and ammonia- nitrogen concentration were closely related and that when dietary crude protein percentage increased, concentration of plasma-urea N and solubility and degradability of protein in the rumen of cattle also increased (Cressman *et al.* 1980). Therefore, the differences in ruminal NH_3–N and plasma-urea N concentration across treatments from this study may have been related directly to crude protein level and the extent of crude protein degradation of each feed.

The total volatile fatty acids, acetate, propionate and butyrate production were significantly different ($P<0.05$) across treatments and lowest in sheep fed on CAHA (95.94mM) having the lowest total volatile fatty acid production. This could be as a result of condensed tannin in CAHA which affect volatile fatty acid production (Mashudi *et al*. 2014). Acetate to propionate ratio (C_2:C_3) obtained across treatments (3.03–3.20) is normal according to Anonymous (2013) who stated that under optimal conditions the acetate to propionate ratio should be greater than 2.2 to 1.

There were significant differences ($P<0.05$) across the treatments for total viable bacteria, fungi zoospores and protozoa counts while bacteria counts were similar across the treatments. The more fungi counts obtained in UTCC, UTST and PAHA treatments could be due to high fibre content of these feedstuffs as Bauchop (1979) showed that fungi were more prevalent in ruminants fed high fibre diets than in those fed less fibrous ones. Animals fed CAHA had the least protozoa count and it could be that condensed tannin present in cassava hay had played an important role in debugging protozoal populations. As previously reported by Makkar *et al*. (1995), condensed tannin altered rumen ecology and increased microbial protein synthesis.

Based on the results of this experiment, it could be concluded that the use of PAHA, UTCC, UTST and CAHA as roughage sources improved weight gain of the animals, maintained normal ruminal pH, temperature and ammonia-nitrogen concentration of the rumen. It is therefore recommended that panicum hay, urea-treated corn cob, urea-treated sugarcane top and cassava hay supplemented with concentrate could be fed to ruminants during the long dry season.

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