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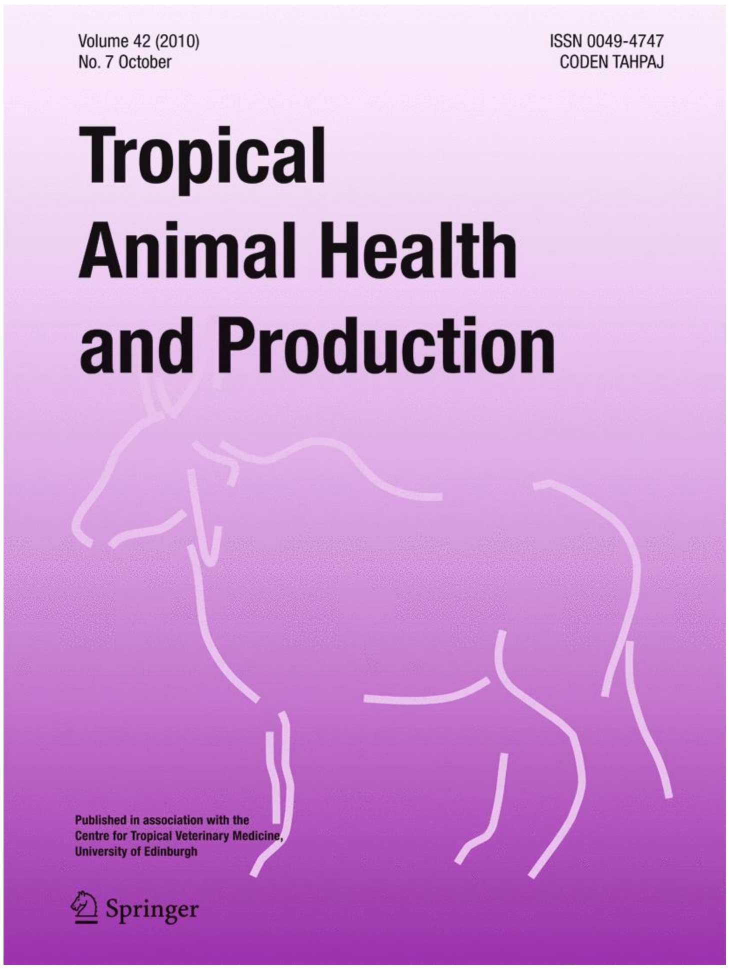

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ORIGINAL RESEARCH

Chemical composition and *in sacco* degradability of four varieties of cassava leaves grown in Southwestern Nigeria in the rumen of sheep

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Abstract The nutritive value of leaves of four varieties of cassava (MS 6, TMS 30555, *Idileruwa* and TMS 30572) were studied through analysis of their chemical components and degradability of their dry matter (DM) and crude protein (CP) in the rumen of sheep. Results of the chemical analyses showed that the leaves of the four varieties contained different proportions of organic matter which was significantly ($P<0.05$) highest in TMS 30572 with value of 935 g/kg DM, while CP (gramme per kilogramme DM) was significantly highest in TMS 30555 (240), followed by MS 6 (235), TMS 30572 (208) and least in *Idileruwa* (177). Mean metabolisable energy (megajoules per kilogramme DM) was significantly ($P<0.05$) highest in TMS 30572 (8.2) and similar with *Idileruwa* (8.0) but different from TMS 30555 and MS 6, respectively (7.8 and 7.6). The mineral contents (gramme per kilogramme DM) showed that leaves of MS 6 and *Idileruwa* had the highest concentrations of K (2.86) and a significantly lowest value (1.83) in TMS 30555. Also, the highest concentration of Ca and Fe (6.81 and 6.23) was recorded in MS 6. The highest Ca:P of 3.20 was obtained in TMS 30555. DM degradation characteristics and effective degradability varied significantly ($P<0.05$) and were consistently highest in TMS 30572. The washing loss (a) ranged from 15.9% in MS 6 to 21.3% in TMS 30572. TMS 30572 tended to have higher ($P=0.546$) insoluble but fermentable fraction (b) than all other varieties. Moreover, the potential degradability ($a+b$) tended to be higher ($P=0.041$) in TMS 30572 (69.5%) followed by TMS 30555 (67.1%) and the lowest was in *Idileruwa* (42.7%). The highest effective degradability was recorded in TMS 30572 (63.9%) and the lowest in *Idileruwa* (40.7%). The degradation rate constants (c) of *Idileruwa* was significantly higher ($P=0.001$) than those of MS6, TMS 30555 and TMS 30572. The results generally indicated that the leaves could be ranked for their potential feeding value as TMS 30572 (71.5%)>MS6 (65.8%)>*Idileruwa* (63.0%)>TMS 30555 (50.4%). It is therefore concluded from this study that leaves of TMS 30572 and MS 6 have good potential as feed resources for ruminant animals and could be used in ruminant feeding as protein source ingredient.

Keywords Proximate composition · Mineral · *In sacco* degradability · Rumen · Sheep · Cassava leaves

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Introduction

All over the world, different species of livestock are reared in an attempt to meet man's demand for animal protein. The high demand for animal protein can be met most rapidly by increasing ruminant livestock production. In the tropics, ruminant animals are raised predominantly on grasses, which are inherently poor in nutritive value. The availability of these grasses is also seasonal. Ruminant livestock raised in this region, therefore, tend to reflect the cyclical variation in the quantity and quality of these available forages (Bamikole and Babayemi 2008). Ruminant animals, because they have pre-gastric fermentative digestion of feed, generally do not compete with human beings for vital quality feed resources. In Nigeria, the cost of producing nutritious supplemental feed for ruminants is very high, and forage crops are not available all the year round. Cassava (*Manihot esculenta* Crantz) is one of the most important staple food crops grown in tropical Africa. Traditionally, cassava tuberous roots are a major source of carbohydrates in human diets and are processed by various methods into numerous products utilised in diverse ways according to the local customs and preferences (Hahn 1988). Unlike the roots that are essentially carbohydrates, cassava leaves are a good source of protein and vitamins, which can provide a valuable supplement to the predominantly starchy diets and feed and compare favourably with other green browses generally regarded as good protein sources. According to Wanapat (2008), cassava foliage can be used for animal feeding and a high edible biomass yield, ranging from 3.8 to 7.9 tonnes DM ha^{-1}. However, cassava foliage contains anti-nutritional substances in the form of tannins (Kiyothong and Wanapat 2003) and hydrocyanic acid (HCN; Khang and Wiktorsson 2006). The inverse relationship between high tannin levels in the forage and palatability, voluntary intake, digestibility and N retention in herbivores is well established (Bhatta et al. 2005). Thang et al. (2010) recommended that a management strategy to reduce negative effects of secondary compounds could be to mix the foliages, which could positively affect voluntary intake, rumen degradation and digestibility of diet as described by Castro-Gonzalez et al. (2007). In recent years, the Nigerian government has paid more attention to large-scale production of cassava for export purposes. This has resulted to the multiplication of improved varieties of cassava by government agencies and research institutes. The implication of this therefore is that after harvesting and processing of the tuberous roots, the large quantities of the leaves will be 'wasted', if not explored as animal feed. This study was designed to determine the nutrient profile, dry matter (DM) and crude protein (CP) degradability of four varieties of cassava leaves grown in Southwestern Nigeria.

Materials and methods

Collection and preparation of samples

The cassava foliage (leaves and petioles) used was hybrid and local varieties which included TMS 30572, TMS 30555, MS6 and *Idileruwa* (Yoruba). Samples of the foliage were harvested fresh from the Agricultural Media Resources and Extension Centre (AMREC), Demonstration Farm of the University of Agriculture, Abeokuta, Nigeria. Samples were taken on ten occasions after root harvesting throughout the harvesting season between October and February and were then oven-dried and bulked. The bulked samples were heated in the oven to facilitate easy milling. Of each sample, about two thirds were milled using laboratory hammer mill fitted with a 2.5-mm screen mesh and used for the degradability study, while the remaining one third was milled to pass through a 1-mm screen for chemical analyses.

In sacco degradability measurements

The study was conducted at the Small Ruminant Unit of College of Animal Science and Livestock Production Teaching and Research Farm, University of Agriculture, Abeokuta, Southwestern, Nigeria. The protocol for this study was approved by the Ethical Review Committee of the University of Agriculture Abeokuta, Nigeria, before the commencement of the experiment. The *in sacco* DM degradability was determined using three rumen fistulated rams with an average weight of 27±0.08 kg, fitted with permanent rumen cannulae (7 cm diameter, 4 cm aperture and 5 cm aperture lead). The rams were fistulated following sedation with 2% xylazine hydrochloride (Xylaz® Kepro Vet. Holland) at the rate of 0.3 mg/kg followed by administration of inverted L-block at the right flank area with 2% lignocaine hydrochloride (Liga ADR® SAI Parenterall, India). Following fistulation, intramuscular injection of 5% tramadol (Tramal® Ciron Drugs and Pharmaceuticals Ltd., Boisar) at 3 mg/kg was administered for 3 days to provide postoperation analgesia. In addition, penicillin/streptomycin (Penstrep 20/25, Kepro, Holland) injection was administered intramuscularly for 5 days. The rams were housed in individual pens and offered 800 g of a mixture of *Panicum maximum* and *Gmelina arborea* with 500 g of concentrate a day in two equal feeding instalments. Water and salt lick were provided ad libitum. In order to determine the DM degradability, 5 g samples of milled MS 6, TMS 30555, TMS 30572 and *Idileruwa* were weighed in triplicates into nylon bags (50×180 mm, 41 µm pore size, Polymon China). The bags were hung with slits made on a flexible tube and tied using rubber bands before being suspended in the rumen of sheep via the canula. The bags were incubated in the rumen and withdrawn after 6, 12, 24, 48, 72 and 96 h. After the removal, the bags were kept inside ice cubes to stop fermentation and then rinsed under running tap water until the water became clear and free of all particles. To determine the washing loss at 0 h, the bags were soaked in warm water at 39°C for 30 min in a water bath, washed as above and dried for 48 h at 60°C. The degradability constants were determined using the exponential equation $p = a + b(1 - e^{-ct})$ as described by Orskov and McDonald (1979), using the Neway Excel programme (Chen 1995), where p=DM degradability at time t. The degradation characteristics of the feeds were defined as a=washing loss (readily soluble fraction); $b = (a + b) - a$, representing the insoluble but fermentable fraction; c=the rate of degradation of b and the lag phase $(L) = (1/c)\log_e[b/(a + b - a)]$ (Orskov and Ryle 1990). Potential degradation (PD) was estimated as $(a+b)$, while effective degradability (ED) of DM was calculated according to Dhanoa (1988) using the formula: $ED = a + [bc/(c + k)]$ at rumen outflow rate (k) of 0.05 h^{-1}.

Chemical analyses

Samples were analysed for their respective proximate compositions according to the official methods of analyses described by AOAC (1995). Fibre fractions were analysed by the method of Van Soest and Robertson (1985). Cellulose was taken as the difference between ADF and ADL, while hemicellulose was calculated as the difference between NDF and ADF. HCN content was determined using the method of Bradbury et al. (1999). Condensed tannin (CT, polyphenols) was estimated by the HCL-butanol method as outlined by Porter et al. (1986). For the mineral component analysis, the samples were thoroughly washed in water to remove extraneous matter and then dried at 60°C for 3 days in an oven before milling. The samples were digested by nitric and perchloric acids mixture (ratio= 4:1, *v*/*v*), and the concentrations of the minerals in the samples were determined by an atomic absorption spectrophotometer at wavelength of 550 nm (Buck scientific model 200a; Buck Scientific, East Norwalk, CT 06855, USA).

Calculation of organic matter digestibility and metabolisable energy

The organic matter digestibility for MS 6, TMS 30555, TMS 30572 and *Idileruwa* was estimated using the equation developed by Jarrige (1989) as follows:

$$\begin{aligned} OMD = 91.9 &- (0.355 \times \text{NDF percentage}) \\ &+ (0.387 \times \text{ADF percentage}) \\ &- (2.17 \times \text{ADL percentage}) \\ &- (0.39 \times \text{EE percentage}) \end{aligned}$$

Where NDF=neutral detergent fibre, ADF=acid detergent fibre, ADL=acid detergent lignin and EE=ether extract.

Metabolisable energy was estimated using two separate equations and the mean values taken. The first one was according to MAFF (1984) equation: $ME = \text{DOM percentage} \times 0.15$, where $\text{DOM percentage} = (0.92 \times \text{OMD percentage}) - 1.2$, while the second was according to De Boever et al. (1997) as follows:

$$\begin{aligned} ME = 12.86 + 0.0265EE - 0.0056ADF - 0.0153ASH \\ - 0.0253ADL \end{aligned}$$

where EE=ether extract, ADF=acid detergent fibre and ADL=acid detergent lignin.

Statistical analyses

Data generated from chemical analysis data were subjected to one-way analysis of variance, while the degradability data were analysed using the linear models procedure (PROC GLM) of SAS (2000) in a completely randomised design. The significant differences between treatment results were determined at 5% probability level using Duncan's multiple range test of SAS (2000) package.

Results

The proximate composition of cassava leaves were presented in Table 1. The results showed that the DM was lowest in TMS 30555 and highest in TMS 30572 with significant differences ($P<0.05$) between TMS 30572, MS6 and TMS 30555 and *Idileruwa*. The CP content in *Idileruwa* was lower than other varieties but was significantly higher ($P<0.05$) in TMS 30555 than other varieties. The ash content of 65 g/kg DM was significantly ($P<0.05$) lowest in TMS 30573 and was highest in MS 6 with a value of 161 g/kg DM. The mean metabolisable energy values significantly ($P<0.05$) ranged from 7.6 in MS 6 to 8.2 in TMS 30572. The mean NDF content was 621 g/kg DM with a significant ($P<0.05$) range of 596 g/kg DM in MS6 to 662 g/kg DM in *Idileruwa* (Table 2).

The mineral composition of the different varieties of cassava leaves as presented in Table 3 indicates that values of Ca, P, Mg, Cu and Ca:P were statistically similar for all the varieties. The values of *Idileruwa* and MS6 differed significantly ($P<0.05$) for Fe and TMS 30572 and *Idileruwa* for Mn. The Zn content of 1.37 g/kg DM was highest in *Idileruwa* and was significantly ($P<0.05$) different from other varieties that have similar values of 0.65, 0.68 and 0.60 g/kg DM for MS 6, TMS 30572 and TMS 30555, respectively.

Data on DM degradability are presented in Table 4. The DM degradability increased with the increasing time of incubation. After 96 h of incubation, the DM degradability ranged from 50.4 in TMS 30555 to 71.5% in TMS 30572. At all incubation times, except the 6 h incubation period, TMS 30572 had higher degradability. At the 12, 48 and

Table 1 Dry matter (DM, gramme per kilogramme), proximate composition and estimated metabolisable energy of four varieties of cassava leaves

Component	Varieties				
	MS6	TMS 30572	TMS 30555	*Idileruwa*	SEM
Dry matter	900a	901a	884b	891b	2.09
Organic matter	839c	935a	841bc	847b	1.74
Crude protein	235b	208c	240a	177d	0.60
Ether extract	73.0a	70.0ab	60.0b	66.0ab	3.61
Ash	161a	65.0c	160ab	153b	1.74
Tannin (mg/l)	1.0d	2.2b	1.4c	3.8a	0.04
HCN (mg/kg DM)	83.7a	78.6a	58.5b	86.7a	2.85
Metabolisable energy (ME, MJ/kg DM)					
ME 1	11.8c	12.0b	11.8c	12.0b	0.02
ME 2	3.5b	4.3a	3.8ab	4.0ab	0.14
Mean ME	7.6c	8.2a	7.8bc	8.0ab	0.08

Along the same row with different lowercase letters are significantly ($P<0.05$) different

ME 1 was estimated using De Boever et al. (1997) equation ($ME=12.86+0.0265\ FAT-0.0056\ ADF-0.0153\ ASH-0.0253\ ADL$)

ME 2 was estimated according to MAFF (1984) equation ($ME=DOM\%\times0.15$)

96 h incubation times, the DM disappearance of the leaves of TMS 30572 was significantly higher than the other varieties. The washing loss (*a*) ranged from 15.9% in MS 6 to 21.3% in TMS 30572. TMS 30572 tended to have higher ($P=0.546$) insoluble but fermentable fraction (*b*) than all other varieties. Moreover, the potential degradability ($a+b$) tended to be higher ($P=0.041$) in TMS 30572 followed by TMS 30555, and the lowest was in *Idileruwa*. The highest effective degradability was recorded in TMS 30572 and the lowest in *Idileruwa*. The degradation rate constants (*c*) of *Idileruwa* was significantly higher ($P=0.001$) than those of MS6, TMS 30555 and TMS 30572. The CP disappearance and the estimated parameters of leaves are given in Table 5. The CP disappearance from nylon bag incubated in rumen increased with increasing incubation times. At all incubation time, the CP disappearance of the leaves of TMS 30555 was significantly higher than those of MS 6, *Idileruwa* and TMS 30572. After the 96 h incubation, the CP disappearance ranged from 47.3% in TMS 30572 to 58.1% in TMS 30555. The estimated parameter *a* was significantly higher ($P<0.05$) in *Idileruwa* than the other three varieties. The insoluble but fermentable fraction (*b*), potential degradability ($a+b$) and the rate of degradation constant (*c*) were significantly higher in TMS 30555 than MS6, *Idileruwa* and TMS 30572, respectively.

Discussion

The chemical composition of four cassava varieties presented in this study showed that their CP contents compared favourably with and, in certain cases, surpassed those reported for some leguminous browse plants grown in West Africa (Aletor and Aladejimi 1989). The CP contents reported for MS 6, TMS 30555, *Idileruwa* and TMS 30572, respectively, were lower than the values of 354, 332, 363 and 343 g/kg DM reported by Ayodeji (2005). However, the CP contents fall within the values of 20% to 23% reported by Khang (2004) and values of 18.4% and 18.55% obtained by Bunyeth and Preston 2006 and Alli-Balogun et al. (2003), respectively. The variation in the CP contents may be attributed to varietal differences, period and stage of harvesting and the physiological plant part and fraction used for the study. The NDF, ADF and ADL values reported for the four varieties fell within values reported in literature. For example, Khang (2004) reported NDF range of 26% to 51% and ADF contents of 19% to 37%. Wanapat et al. (2000) obtained NDF, ADF and ADL values of 29.6%, 24.1% and 4.7%, respectively, for dried cassava leaves. Values obtained in this study for NDF, ADF and ADL, respectively, for the four varieties were above the values obtained by the different researchers cited. The fact

Table 2 Proportion of cell wall contents (gramme per kilogramme DM) in the leaves of four varieties of cassava

Component	Varieties				
	MS6	TMS 30572	TMS 30555	*Idileruwa*	SEM
Neutral detergent fibre	596c	613b	613b	662a	2.98
Acid detergent fibre	546a	480b	529a	418c	7.58
Lignin	293a	254b	279a	235b	5.25
Cellulose	253a	226b	250a	172c	5.36
Hemicellulose	50.4c	132b	80.8c	245a	10.6

Along the same row with different lowercase letters are significantly ($P<0.05$) different

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Table 3 Mineral composition of four varieties of cassava leaves (gramme per kilogramme DM)

Component	Varieties				
	MS6	TMS 30572	TMS 30555	*Idileruwa*	SEM
Macro-minerals					
Na	0.29	0.42	0.49	0.28	0.08
K	2.96a	2.61a	1.83b	2.86a	0.16
Ca	6.81	5.65	6.56	4.92	0.79
P	2.19	2.38	2.05	2.93	0.38
Mg	0.86	0.65	0.91	0.92	0.09
Ca:P	3.11	2.37	3.20	1.68	0.21
Micro-minerals					
Cu	0.23	0.11	0.17	0.13	0.04
Fe	6.23a	3.83b	3.72b	3.37b	0.57
Zn	0.65b	0.68b	0.60b	1.37a	0.39
Mn	1.72b	1.03c	1.20c	2.25a	0.57

Along the same row with different lowercase letters are significantly ($P<0.05$) different

that the varieties contained above 50% NDF shows that they have high proportions of soluble carbohydrate, which is good for proper rumen function (Oni et al. 2008).

The mineral composition of the cassava leaf varieties indicated that Ca, Fe, K and P are the most abundant minerals. According to Onwuka and Akinsoyinu (1988), the presence of mineral elements in animal feed is vital for the animals' metabolic processes. The results obtained for Ca in this study for the various varieties were higher than those cited by Ayodeji (2005) and (Ngamsaeng et al. 2006).

Table 4 Dry matter degradability and degradability characteristics of four varieties of cassava leaves (percent)

Incubation time (h)	Varieties					
	MS6	TMS 30572	TMS 30555	*Idileruwa*	SEM	*P*
6	26.3	14.1	12.9	20.9	3.97	0.284
12	33.3a	34.2a	23.8b	33.3a	1.68	0.015
24	46.8	49.7	29.4	43.6	5.16	0.229
48	56.1ab	61.8a	43.4c	56.9ab	3.19	0.045
72	60.9	63.8	44.9	59.0	6.77	0.346
96	65.8b	71.5a	50.4c	63.0b	2.71	0.002
Degradability parameters						
a	15.9	21.3	21.1	16.8	1.47	0.126
b	43.0	48.2	46.0	25.9	4.17	0.546
a+*b*	58.9b	69.5a	67.1a	42.7c	2.65	0.041
c	0.07c	0.38b	0.42b	0.58a	0.16	0.001
L	3.73	5.30	7.30	6.33	1.38	0.164
Ed 0.05 h^{-1}	41.0b	63.9a	62.2a	40.7b	0.24	0.038
RSD	6.88	10.9	5.17	6.64	2.05	0.416

Along the same row with different lowercase letters are significantly different ($P<0.05$)

SEM standard error of mean

a=Washing loss and soluble fraction

b=Insoluble but fermentable fraction

a+*b*=Potential degradability

c=Rate of degradation of B (fraction per hour)

L=Lag phase (hour)

Ed=Effective degradability at an outflow rate of 0.05 h^{-1}

RSD=Residual standard deviation

Table 5 In situ crude protein degradability and estimated parameters of four varieties of cassava leaves (percent)

Incubation time (h)	Varieties					
	MS6	TMS 30572	TMS 30555	*Idileruwa*	SEM	*P*
6	22.6b	21.6b	27.7a	20.0b	0.11	0.019
12	29.5b	29.6b	38.0a	28.3b	0.24	0.035
24	37.8b	36.3b	48.8a	36.5b	0.27	0.046
48	43.9b	42.0b	54.6a	44.6b	0.48	<0.001
72	48.1b	47.1b	56.7a	48.0b	0.11	0.052
96	50.5ab	47.2b	58.1a	49.1b	0.06	0.054
Degradability parameters						
a	16.9b	16.9b	17.2ab	19.2a	0.35	0.016
b	6.33b	3.54c	9.49a	6.33b	1.48	<0.001
a+*b*	23.2	20.5	26.7	25.5	1.45	0.126
c	1.62b	1.42b	3.01a	1.35b	0.01	<0.001
Ed 0.05 h^{-1}	23.0b	20.4b	26.5a	25.2a	0.72	0.001

Along the same row with different lowercase letters are significantly different ($P<0.05$)

SEM standard error of mean

a=Washing loss and soluble fraction

b=Insoluble but fermentable fraction

a+*b*=Potential degradability

c=Rate of degradation of B (fraction per hour)

Ed=Effective degradability at an outflow rate of 0.05 h^{-1}

The high Ca content of the varieties could have resulted from the season the leaves were collected coupled with the pH of the soil. The P values obtained were higher than those reported by Onwuka and Akinsoyinu (1988) and Ayodeji (2005), respectively. They were however lower than values cited by Wanapat (2001) who also worked on dried cassava leaves and cassava hay. Magnesium values were lower than those reported by (Onwuka and Akinsoyinu 1988) but compare favourably and in fact higher than values reported by Ayodeji (2005) and Ngamsaeng et al. (2006). Na and Cu were low as indicated in the results. This buttresses the reason why NaCl supplementation is advised in goat and sheep nutrition where browse is the sole feed. The supplementation of Fe may not be necessary since most varieties contained fairly high contents of Fe. However, the values obtained for K were higher than values obtained by the various researchers earlier cited. The K value for TMS 30555 was within the value cited by Onwuka and Akinsoyinu (1988). The ratios of Ca to P were moderate in all the varieties. NRC (1981) recommended a Ca:P between 1 and 2 for ruminants which was within the values obtained in this study. This may be as a result of relatively moderate level of P in all the varieties. Therefore, values obtained for most of the minerals in these varieties showed that cassava leaves can meet the mineral requirements of ruminants (NRC 1981) except Na. The major minerals appeared adequate for ruminant animals based on the recommendation of 0.71–0.21 g/100 gMg (ARC 1980; Suttle 1983), 0.5–1.0 g/100 gK (McDowell 1992), 0.01–0.25 g/100 gNa (Fettman et al. 1984) and 0.17–1.53 gCa (NRC 1989).

The DM disappearance from nylon bags incubated in rumen increased with increasing incubation time. Almost at all incubation times, the DM disappearance from the leaves of TMS 30572 was highest, and this was a reflection of its better nutritive value than other varieties. The less than 50% DM reported for 48 h degradation for TMS 30555 was likely to have been caused by its high contents of cell wall especially ADF and ADL. Lignin has been implicated in rations with depressed digestibility (Van Soest 1994) due to its effect in lowering the rate of microbial colonisation of such high fibre feed (Silva and Orskov 1988). The extent of DM disappearance after 48 h of incubation was good for TMS 30572 and MS 6, average for *Idileruwa* and poor for TMS 30555. This implies good digestibility potential for TMS 30572 and MS6 and average digestibility for *Idileruwa* when harnessed as feed resources for ruminant livestock, as 48 h degradability is often considered to be equivalent to digestibility (Bhargava and Orskov 1987). Forty-eight-hour DM degradation value for TMS 30572 in this study was as good as or better than value reported for some species of *Ficus* plant (Bamikole et al. 2004) and

Erythrina brucei (Larbi et al. 1996). The *a* fractions of TMS 30555, *Idileruwa* and TMS 30572 fell within the range of 16.3–33.7% reported for four browse species (Smith et al. 1995). With the exception of *Idileruwa*, the proportion of *b* (10.8–37.3%) and a+*b* (25.6–51.4%) fractions reported in the four browse species were, however, inferior to values obtained for MS 6, TMS 30555 and TMS 30572. The *a*+*b* values of TMS 30572 and TMS 30555 are outstanding but ranked lower than potential degradability of highly degradable fodder tree species (*Millettia thonningii*, 'ito': PD=814 g/kg and *Albizia lebbeck* 'sivis': PD=940 g/kg) reported by Larbi et al. (1996), Lablab (PD=737–847 g/kg) reported by Mupangwa et al. (2003) as well as *Ficus exasperata* (PD=85.76%), *Spondias mombin* (PD=96.69%), *Tectona grandis* (PD=65.94%) and *Terminalia catappa* (PD=73.59%) reported by Ikhimioya et al. (2005).

The rate of degradation *c* that was best in *Idileruwa* and least in MS 6 was a reflection of the lignin contents of the incubated materials, and this corroborated observations made in previous studies (Sandoval-Castro et al. 2005; Bamikole and Babayemi 2008). Better intake of *Idileruwa* than other varieties could be predicted in livestock based on their respective *C*-values, as this signals the potential ruminal load of the feed. According to Preston (1986), the rate of degradation is an important parameter in the assessment of fermentation of crop residues in the rumen. The high Ed (K=0.05) of the DM contents of the cassava varieties is most likely a result of high rate of degradation observed, suggesting therefore that they could have low fill values hence high intake and animal productivity, as Ed is a better index of feed quality (Adjorlolo et al. 2001).

Estimates for cassava leaves' CP degradation characteristics and disappearance from incubation bags showed significant (P<0.05) differences in the parameters measured. Values of Ed of CP obtained in this study were lower than values of 63.1% and 64.7% reported by Chanjula and Sornnok (2007) for cassava hay and cassava leaves, respectively. According to Chanjula and Sornnok (2007), CP degradability of cassava hay in the intestinal (mobile bag techniques) was significantly higher than for *Leucaena* foliage. This was probably due to the high ruminal by-pass protein in cassava hay (Reed et al. 1982). In this study, CT in the leaves was present at 1.00–3.83 mg/l. This may have led to increased absorption of essential amino acid (EAA) from the small intestine and increased ruminal productivity without affecting voluntary feed intake (VFI), thus improving the efficiency of feed conversion. Terrill et al. (1992) and Wang et al. (2000) reported that medium CT concentrations (30–40 g/kg DM) had no effect on VFI but reduced protein solubility and degradability in the rumen (Min et al. 2003), and increased the absorption of EAA from the small intestine (Barry and McNabb 1999).

Conclusion

The study confirmed earlier reports that in situ nylon bag technique could be used to rank feed in terms of DM and CP degradation. It is concluded from this study that leaves of TMS 30572 and MS 6 have good potential as feed resources for ruminant animals and could be used in ruminant feeding as protein source ingredient. Based on their DM and CP degradation performance of the varieties, further studies are therefore recommended to determine whether the observed superiority in DM and CP degradation could be translated into greater animal output, which is a better determinant of forage quality (Moore et al. 1990).

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