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Effect of feeding cassava and/or Stylosanthes foliage on the performance of crossbred growing cattle

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Abstract The effect of feeding different levels of cassava foliage *(Manihot esculenta*, Crantz) and/or *Stylosanthes guianensis* foliage on the growth and digestibility was studied using twenty eight 6-month-old crossbred growing cattle (50% local Yellow cattle and 50% Sindhi) (both *Bos indicus*) weighing on average 114 kg at start. All animals were fed a basal diet consisting of urea treated rice straw (URTRS) fed *ad libitum*, 0.87 kg concentrate and 0.22 kg molasses on dry matter (DM) basis. The treatments were four supplements: soybean meal, cassava foliage, stylosanthes foliage or a mix of stylosanthes foliage and cassava foliage all giving the same nitrogen intake. The consumption of tannins and hydrogen cyanide (HCN) were significantly higher in groups fed a mixture of foliages compared with only cassava foliage, respectively. There were 30% and 19%, respectively, higher live weight gain in the group fed a mixture of foliages as compared to the groups fed only cassava or stylosanthes. The factors of low organic matter and high level of HCN in the diet when feeding only cassava foliage might explain the negative effects on intake, neutral detergent fibre digestibility and nitrogen retention, and resulted in lower growth rates.

Keywords Growing cattle · Cassava foliage · Stylosanthes foliage · Apparent digestibility · Growth rate

Abbreviations

ADF	acid detergent fibre
CP	crude protein
DM	dry matter
FCR	feed conversion ratio
GLM	general linear model
HCN	hydrogen cyanide
LW	live weight
LWG	live weight gain
ME	metabolisable energy
N	nitrogen
NA	not analysed
NDF	neutral detergent fibre
OM	organic matter
URTRS	urea treated rice straw

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Introduction

In tropical countries cattle production is often based on crop residues and by-products such as rice straw as major roughages sources during the long dry season. Large improvements in ruminant productivity can be achieved by adding small amounts of supplements that provide essential nutrients to the basal feed of low quality forage (Preston and Leng 1987). Recently interest has been focused on foliage from cassava (*Manihot esculenta,* Crantz) as a supplemental feed for ruminants. Cassava is known as a highly productive tropical crop that is traditionally cultivated to produce roots for human consumption or for starch production. Ravindran and Rajaguru (1988) reported the yield of cassava leaves to be as much as 4600 kg dry matter (DM) ha^{-1} when taken as a by-product at root harvesting. In Vietnam lower yields of cassava leaf residue were reported by Liem et al. (1998). Cassava foliage has been evaluated as a protein supplement for cattle (Man and Wiktorsson 2001; Khang and Wiktorsson 2006). A diet based on urea treated rice straw with a supplement of cassava hay decreased the amount of concentrate required by 3 kg $head^{-1}$ day^{-1} without negatively affecting milk yield in lactating dairy cows (Wanapat et al. 2000). Hay of cassava leaf and stem was a good ruminant feed with a high voluntary feed intake (3.1% of the live weight (LW)) and DM digestibility (71%) (Wanapat et al. 1997) and could increase the ratio of protein to energy, resulting in increasing productivity (Leng 1997).

Supplementation of cereal crop residues with leaves of legumes has been reported to increase DM intake (Mosi and Butterworth 1985) and DM digestibility of young plant material was found to vary between 60 and 70% (Mannetje and Jones 1992). Stylosanthes (*Stylosanthes guianensis* CIAT 184) was found to grow well and produce 12 to 17 tonnes DM ha^{-1} $year^{-1}$ with 14 to 18% crude protein (CP) in the DM (Kiyothong et al. 2005) and could be preserved as hay with high palatability for ruminants (Satjipanon et al. 1995). Both cassava and stylosanthes foliage contain anti-nutritional substances in the form of tannins (Kiyothong 2003) and cassava foliage also contain HCN (Gomez 1985; Wanapat et al. 2000; 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 (Silanikove 1994; Bhatta et al. 2005). However, 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). Kiyothong (2003) found that milk yield did not reduce when cassava hay in combination with stylo hay replaced 33% of the concentrate as feed for dairy cows.

The objective of the present study was to determine the effect of feeding different levels of cassava foliage (*Manihot esculenta*, Crantz*)* and/or *Stylosanthes guianensis* on the *in vivo* digestibly, feed intake and growth rate of crossbred growing cattle fed a basal diet of urea treated rice straw.

Materials and methods

Location and climate of the study area

The experiments were conducted at the BaVi Cattle and Forage Research Centre at Sontay, Hatay province in Northern Vietnam. The centre is located in the buffer zone between the mountainous area and the delta at E105°25 longitude and N21°06 latitude, and is 220 m above sea level. The climate is tropical monsoon with a wet season between April and November and a dry season from December to March. The rainfall during 2006 was about 1900 mm. The mean temperature and humidity during the experiments were 23.5 to 30.2°C and 72.8 to 81.2%, respectively. The study was carried out from September to December 2006.

Experimental animals and feeds

Twenty eight crossbred growing male cattle (50% local Yellow cattle and 50% Sindhi) (both *Bos indicus*) at around six months of age with an average live weight of 113.7 kg (SD=12.3) at the start were used in the experiments. The animals were selected at the same approximate age and were individually identified by numbered ear tags. Before the adaptation period, all the experimental animals were treated against intestinal parasites using DeptinB™ (2 ml/100 kg LW) and were vaccinated against pasteur-

ellosis and 15 days later for Foot and Mouth Disease. The animals were weighed after the adaptation period when the feed intake was stable.

The feeds used in the experiments were urea treated rice straw (URTRS), molasses, concentrate and supplemental feed consisting of soybean meal, cassava foliage and/or stylosanthes foliage. The cassava and stylosanthes crops were planted in Ninh Binh province 60 km south east of the experimental site. Before planting in April organic fertilizer was applied for both cassava and stylosanthes at the rate of 10,000 kg ha^{-1}. For the stylosanthes 350 kg ha^{-1} of P and 150 kg ha^{-1} of K were added. The cassava foliage was collected at the first harvesting time three months after planting. At harvesting time the cassava was 115 to 125 cm high and was cut 30 cm above the ground and chopped into 3 to 4 cm lengths by a cutting machine. The stylosanthes foliage was collected 4 months after planting, cut at 30 cm above ground and chopped by hand to 7 to 10 cm length to reduce loss of green leaves. After cutting the foliages were sundried immediately for two to three days to reach a moisture content of less than 12% and were packed in separate plastic bags. Before the adaptation period the separate cassava and legume foliages were re-sundried for a second time to prevent mould. The concentrate was mixed every 15 days, and consisted of 40% maize meal, 40% cassava meal, and 20% green bean husks. For preparation of URTRS, urea solution (4 kg urea plus 0.5 kg of salt dissolved in 80 L of water) was sprinkled onto 100 kg of dried rice straw that was spread out on a plastic sheet placed on the ground. The URTRS was then stored in an airtight plastic bag for three weeks before feeding.

Experimental design and treatments

In the growth trial, 20 cattle were randomly allocated to four treatments in a Completely Randomized Design (CRD) with 5 animals in each group. The daily rations for the cattle in each treatment consisted of a basal diet of urea treated rice straw fed *ad libitum* (115% of the individual average intake of the previous week), 0.87 kg concentrate, 0.22 kg molasses, and one of the following supplements: the control group 0.26 kg soybean meal, the cassava (CA) group 0.95 kg cassava foliage, the stylosanthes (STY) group 1.01 kg stylosanthes foliage and the mixture (CASTY) group 0.49 kg of stylosanthes foliage and 0.49 kg of cassava foliage all on DM basis. The amount of cassava foliage and stylosanthes foliage offered was equal to 110% of the fresh intake in the adaptation period and was adjusted to the individual average intake of the previous week. The supplementation of nitrogen was similar in all treatments.

In the digestibility study, 8 cattle were randomly assigned to four treatments in a repeated Latin square design (4×4). The treatments were the same four diets as in the growth trial. The animals were kept in individual metal metabolism cages, which were designed with an upper floor and a lower floor allowing separation of faeces and urine.

Feeding and management

In the growth trial, the animals were housed in individual pens with roofing and concrete floor. The feeds were offered twice per day, in the morning (07.30 h) and afternoon (16.30 h). At each feeding occasion, the concentrate was supplied first to the animals, and then the supplemental feed was given in a separate bucket with the molasses. Molasses, which was completely ingested, were only sprinkled on the feed in the morning. Finally, the animals were offered URTRS. Each animal had free access to clean drinking water and a mineral lick block containing Ca 90 g, P 90 g, Na 150 g, Mg 5 g, Fe 10 g, Mn 6000 mg, Cu 800 mg, Co 400 mg, I 50 mg and Se 100 mg per 1 kg block. The experimental period lasted for 105 days including 15 days of adaptation.

For the digestibility study, each experimental period consisted of 26 days: 14 days for adaptation, 5 days of data collection and an extra 7 days for resting outside cages, when all the experimental animals were given a diet of elephant grass *ad libitum* and 1.5 kg of concentrate. During the 14 days of the adaptation period, feeds were offered individually to the animals according to planned treatments.

Data collection

During the growth trial, daily feed consumption was recorded and refusals collected for individual animals in the morning of the next day. The intake of concentrate, supplemental feeds and urea treated rice straw was

measured daily, based on the amount of feeds offered and refused. The total feed intake was calculated as the sum of the intake of the feed components. At the start and the end of the growth trial, all animals were weighed individually for two consecutive days in the morning before feeding, and the mean taken as the initial and final weight. During the growth study, the LW was recorded every 15 days with the same procedure. Growth rate of each animal was calculated from the average daily live weight gain (LWG) at each 15 days measurement change over the time of experiment. Feed conversion ratio (FCR) was calculated as kg feed consumed kg^{-1} gain, kg CP intake kg^{-1} gain and MJ ME kg^{-1} gain.

During the digestibility study, the feeds offered and refused were recorded daily for individual animals and weighed before new feed was added. The faeces and urine excreted by individual animals were collected and measured daily. During the collection time the faeces was sampled and frozen and stored for future analysis. Urine was collected in a bottle containing 800 to 1000 ml of 10% sulphuric acid to preserve nitrogen and around 1% of the total urine excreted was sampled and stored at 4°C for further analysis. The pH value of urine was tested by litmus paper to ensure that the pH value of the urine in the collection bottle was kept below 3.0.

The temperature and humidity in the animal house were measured three times per day at 07.00 h, 14.00 h, 21.00 h to investigate the effect of the environment on feed intake and performance of the animals.

Chemical analysis

During the growth trial, the feeds offered and individual feed refusals were sampled daily and pooled to a sample for each fifteen days. During the digestibility trial, the feeds offered and refused were sampled daily and then pooled for the whole collection period. The faecal and urine samples of each animal were pooled by period to a sample. Samples of feeds, refusals and faeces were analysed for DM, ash, CP, ether extract (EE), neutral detergent fibre (NDF) and acid detergent fibre (ADF). The urine samples were analysed for DM, CP and ash. The DM (ID 930.15), CP (ID 976.05), and ash (ID 942.05) were analysed according to the standard methods of AOAC (1990). The EE was analysed by ISO (6492:1999) and NDF and ADF concentrations were determined according to the procedure of Van Soest et al. (1991). Total tannins (ID 30.018) were analysed according to AOAC (1975) and HCN content of the cassava foliage by the method of Ikediobi et al. (1980).

In vitro gas production

The cassava and stylosanthes foliage, soybean meal, URTRS and concentrate feed samples were incubated *in vitro* with rumen fluid in calibrated glass syringes as described by Menke and Steingass (1988), and modified by Makkar et al. (1995). The procedure was followed by weighing 200 mg substrate into each numbered syringe placing them in an incubator at 39°C. The solution of distilled water, buffer solution, macro mineral solution, micro mineral solution and resazurin solution was prepared in a round flat-bottomed flask and warmed to 39°C and the reducing solution was added. Then the solution was placed in a water bath at 39°C on a magnetic stirrer and CO_2 gently bubbled through until the blue colour turned to pink and then clear. The buffer was adjusted to pH 7.0–7.3. The rumen fluid was collected and pooled from three animals, and filtered through three layers of gauze. The rumen liquid was poured into the artificial saliva with ratio of 2:1 of artificial saliva and rumen fluid and mixed by magnetic stirrer during the whole process. Samples were done in triplicate. The blanks (control), i.e. rumen fluid and artificial saliva mixture (ratio of 2:1) without feed sample, were included at the beginning, in the middle of the set, and at the end. Next 30 ml of the solution was added to each syringe using a dispenser. The volume of a syringe was 100 ml. The syringe was filled, the clip opened and the syringe's plunger gently pushed so that all the air was removed. Syringe pistons were lubricated with vaseline to ease their sliding and to prevent escape of gas. Readings of gas volume were recorded after 3, 6, 12, 24, 48, 72 and 96 h incubation period.

The results of gas volume reading (means of triplicates) at different times of incubation were fitted to the exponential equation of the form: $P=a+b\ (1 - e^{-ct})$ (Ørskov and McDonald 1979), where P represents gas production at time t, (a + b) the potential gas production, c the rate of gas production.

The energy values of the feeds were calculated based on gas production data according to the equation by Menke and Steingass (1988):

(i) cereal and by-products:

Statistical analysis

The data were analysed statistically as a Completely Randomized design (CRD) by variance analysis (ANOVA) using the general linear model (GLM) procedure of Minitab software version 14.0 (Minitab 2003). The treatment least square means showing significant differences at the probability level of $P<0.05$ were compared using Tukey's pairwise comparison procedure. The statistical model used in the growth trial was $Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$ where Y_{ij} is the dependent variable, μ is the overall mean, α_i is effect of treatment i, and ε_{ij} is a random error. The value of LWG and FCR were tested as covariates in statistical model but as they were not significant ($p>0.05$) they were omitted from the final model.

The statistical model used in the digestibility study was $Y_{ijkl} = \mu + S_i + A_{j(i)} + P_k + T_1 + \varepsilon_{ijkl}$ where Y_{ijkl} is the dependent variable, μ is the overall mean, S_i is the random effect of square, $A_{j(i)}$ is random effect of animal within square, P_k is the fixed effect of period, T_l is the fixed effect of treatment and ε_{ijkl} is random residual error.

All data obtained from *in vitro* gas production test were subjected to ANOVA using the GLM of Minitab software version 14.0 (Minitab 2003).

Results

Chemical composition of the feeds

The chemical composition of the feeds used in the experiments is shown in Table 1. The cassava foliage had a low content of OM (774 g kg^{-1} DM) and a high level of HCN (225 mg kg^{-1} DM). The CP in both foliages was low ranging from 130 to 138 g kg^{-1} DM. The total tannin content was 20.1 and 19.7 g kg^{-1} DM in cassava and stylosanthes foliage, respectively.

The growth experiment

Table 2 shows the mean values of feed consumed for the different treatments. The animals in the control group had significantly higher intake of URTRS than the animals in the groups fed foliages. The total DM intake (DMI) was slightly higher in the group fed cassava and stylosanthes foliage but treatments did not differ significantly. Intake of CP from soybean meal and foliages were similar. The cattle offered the diet with soybean meal had significantly higher intake

Table 1 Chemical composition, digestibility and estimated ME content of the experimental feeds (mean and S.D.)

Item	Cassava foliage	Stylosanthes foliage	URTRS	Concentrate	Soybean meal	Molasses
DM (g kg^{-1})	898 (5.8)	893 (15.0)	454 (51.0)	868 (15.9)	869 (17.5)	561 (4.4)
In g kg^{-1} DM						
OM	774 (70.1)	924 (5.4)	868 (5.7)	959 (1.9)	913 (3.8)	907 (5.6)
CP	138 (11.5)	130 (3.7)	151 (33.7)	98 (8.1)	505 (15.9)	69 (3.9)
EE	47 (2.6)	14 (0.9)	15 (1.0)	27 (3.3)	15 (2.0)	NA
NDF	386 (49.4)	685 (20.7)	725 (42.7)	168 (21.7)	237 (11.5)	NA
ADF	265 (17.9)	465 (30.8)	470 (56.4)	77 (7.6)	97 (10.8)	NA
Tannins	20 (3.4)	20 (2.5)	NA	NA	NA	NA
HCN (mg kg^{-1})	225 (20.1)	NA	NA	NA	NA	NA
Calculated by gas production after 24 hours						
ME (MJ kg^{-1} DM)	6.5 (0.2)	5.4 (0.3)	5.6 (0.3)	6.3 (0.6)	10.2 (0.2)	–

N=6, NA: not analysed. URTRS: urea treated rice straw. IVOMD=*in vitro* organic matter digestibility (%). ME=metabolisable energy (MJ kg^{-1} DM), HCN: hydrogen cyanide

Table 2 Feed and nutrient intake (LS means and SE)

Item	Control	Cassava foliage	Stylosanthes foliage	Cassava and stylosanthes foliage	SE
DM intake (g day^{-1})					
URTRS	2478^{a}	1794^{b}	1769^{b}	1850^{b}	31.2
Foliage	–	2741	2766	2819	31.5
Total *	3831	3834	3859	3911	31.4
DM intake in % of BW	2.8	2.9	2.8	2.8	0.04
DM intake in g kg^{-1} W$^{0.75}$	95	98	96	95	1.5
Nutrient intake (g day^{-1})					
OM	3428^{ab}	3334^{b}	3498^{a}	3471^{a}	27.3
CP from URTRS	393^{a}	284^{bc}	273^{c}	290^{b}	4.3
CP from SF	131	131	129	130	0.7
CP total	624^{a}	516^{bc}	503^{c}	521^{b}	4.5
NDF	2020^{b}	1814^{c}	2114^{a}	2020^{b}	23.6
ADF	1294^{b}	1192^{c}	1386^{a}	1319^{b}	17.7
Tannins	–	22.5^{c}	23.4^{b}	33.5^{a}	0.1
Tannins (g kg^{-1} DM)	–	6.0^{c}	6.2^{b}	8.7^{a}	0.05
HCN (mg day^{-1})	–	251^{a}	–	113^{b}	0.5
HCN (mg kg^{-1} DM)	–	67.9^{a}	–	29.7^{b}	0.3
ME (MJ, day^{-1})	23.8^{a}	23.4^{a}	22.5^{b}	23.4^{a}	0.2

URTRS: urea treated rice straw. SF: supplemental feed. ^{a,b} Mean within rows with different superscripts are significantly different ($P<0.05$). * The total DM intake is including concentrate and molasses, which was completely consumed by all animals

of CP from URTRS compared to the groups fed foliages. The lowest OM and NDF intake was observed in the group offered only cassava foliage. The HCN intake in the group fed only cassava foliage (251 mg kg^{-1} DM) was more than double the HCN intake in the group offered a mixture of foliages.

The effect of substituting soybean meal in the diet with cassava and/or stylosanthes foliage on the LWG is shown in Table 3 and Fig. 1. The LWG was 520 g d^{-1} for animals fed the diet with soybean meal, and 337, 408 and 477 g d^{-1} for the groups given cassava foliage, stylosanthes and the mixture, respectively. The group offered only cassava foliage had lowest LWG and the highest FCR for DM, CP and ME.

The digestibility experiment

The apparent digestibility and nitrogen balance are shown in Table 4. The digestibility of DM and OM were significantly higher in the groups fed soybean meal and stylosanthes foliage in comparison to the group fed only cassava foliage. The lowest NDF and ADF digestibility was observed in the group offered cassava foliage as a sole feed.

Table 3 Weight gain and feed conversion ratio (LS means and SE)

Item	Control	Cassava foliage	Stylosanthes foliage	Cassava and stylosanthes foliage	SE
Initial weight (kg)	112	114	115	114	5.9
Final weight (kg)	158	144	152	157	8.1
LWG (g day^{-1})	520^{a}	337^{b}	408^{ab}	477^{ab}	43.7
FCR (DM kg^{-1} LWG)	7.4^{b}	12.5^{a}	9.8^{ab}	8.3^{ab}	1.1
FCR (CP kg^{-1} LWG)	1.2^{b}	1.7^{a}	1.3^{ab}	1.1^{b}	0.1
FCR (ME kg^{-1} LWG)	46^{b}	77^{a}	57^{ab}	50^{b}	6.7

^{a,b} Mean within rows with different superscripts are significantly different ($P<0.05$). FCR: Feed conversion ratio, LWG: live weight gain

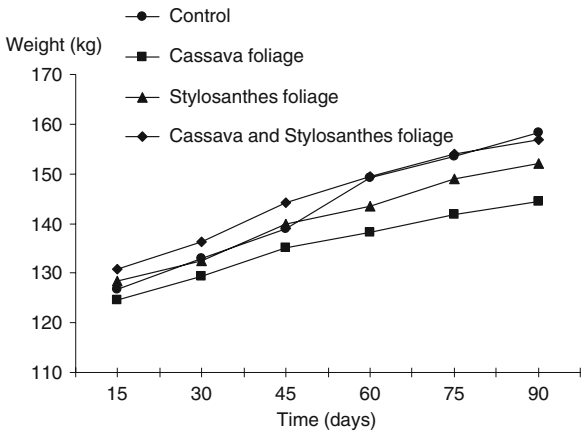

Fig. 1 Accumulated live weight of the animals during the experiment

The faecal N excretion was higher for cattle fed foliages whereas the highest N excretion in urine occurred in group fed soybean meal. The nitrogen retained was higher in the group offered soybean meal than for the groups fed cassava and/or stylosanthes. The N retention in groups fed foliages ranged from 46 to 48 g day^{-1}.

In vitro gas production

Gas production of the cassava foliage, stylosanthes foliage and soybean meal during incubation time is shown in Fig. 2. Gas production did not differ among the experimental feeds during the first 12 hours. The gas volume from soybean meal was significantly higher during 24 to 96 hours of incubation while cassava and stylosanthes foliage did not differ significantly between cassava and stylosanthes foliage in the same period.

Discussion

The overall effects of supplementing the basal diet with stylosanthes foliage sole or together with cassava were positive for animal performance in general and especially live weight gain. A more detailed discussion follows below.

Characterization of the foliages

The lower OM content of cassava foliage that was observed in this study is comparable to that of Dung et al. (2005). The ash content in cassava material is variable, probably depending on the soil characteristics, the fertilizer applied, leaf age, and environmental factors (Awoyinka et al. 1995). The use of whole cassava (leaf+stem) in the foliage processing may have explained the lower OM content. The CP content in both cassava and stylosanthes foliage was lower compared to values reported by Van and Ledin (2002), Kiyothong (2003) and Dung et al. (2005). The content of CP depends on the proportion of leaves and stem, soil fertility and harvesting time. In the present study, a part of the stems was included, which resulted in lower CP.

The fresh cassava foliage contains high levels of cyanogenic glucosides. These glycosides can by the action of either the endogenous enzyme linamarase in damaged plant tissues or the β-glycosidase within the digestive tract of animals (Coursey 1973), liberate free hydrogen cyanide (HCN). The HCN content of cassava foliage can be reduced through sun drying or ensiling up to 63% and 78%, respectively, of the initial value in fresh form (Khieu et al. 2005). The concentration of HCN (225 mg kg^{-1} DM), in this study, was higher than the values of 128 mg kg^{-1} DM reported by Dung et al. (2005) and 145 mg kg^{-1} DM by Phengvichith and Ledin (2007). The HCN concentration is influenced by the nutritional status and age of the plant (Ravindran and Rajaguru 1988), and higher HCN levels were found in leaves from bitter than sweeter varieties (Tewe and Lyayi 1989). In cattle and sheep, HCN can be lethal at 2 to 4 mg HCN kg^{-1} LW (Kumar 1992). In the present study, the average daily intake of HCN ranged from 113 to 251 mg day^{-1} for 115 kg LW, which was lower than the lethal dose stated above. There were no apparent symptoms of HCN toxicity in the animals consuming cassava foliage.

Gas production technique is widely used to assess the nutritive value of feedstuffs. In the present study, the higher gas production of soybean meal as compared to the foliages after 24 hours of incubation may have two possible explanations. First, soybean meal had a very high CP content. Secondly, secondary compounds such as tannin or HCN in the foliages may have hampered the microbial activity (Ben Salem et al. 2002; Min et al. 2005) as suggested by the reduced gas production. Generally, the differences observed in net gas production reflect the energy value of the feeds (Menke and Steingass 1988).

Table 4 DM intake, nutrient intake, apparent digestibility and nitrogen balance in the digestibility experiment

Item	Control	Cassava foliage	Stylosanthes foliage	Cassava and Stylosanthes foliage	SE
Feed intake (g DM day^{-1})					
Concentrate	781	781	781	781	
Molasses	202	202	202	202	
Soybean meal	235	–	–	–	
Cassava foliage	–	853	–	440.2	
Stylosanthes foliage	–	–	911	446.5	
URTRS	2539^{a}	1996^{b}	1877^{c}	2015^{b}	30.7
Total	3757^{b}	3833^{ab}	3772^{b}	3886^{a}	30.8
Nutrient intake (g day^{-1})					
OM	3351^{ab}	3326^{b}	3404^{ab}	3434^{a}	26.7
CP	579^{a}	499^{b}	480^{c}	502^{b}	4.7
CP from URTRS	371^{a}	291^{b}	271^{c}	293^{b}	4.5
CP from SF	118	118	119	119	0.8
NDF	2027^{b}	1907^{c}	2119^{a}	2069^{ab}	22.2
ADF	1294^{b}	1240^{c}	1382^{a}	1339^{ab}	14.5
Digestibility (g kg^{-1}DM)					
DM	662^{a}	596^{c}	632^{ab}	610^{bc}	9.2
OM	700^{a}	631^{c}	668^{b}	646^{bc}	8.7
CP	728^{a}	606^{c}	652^{b}	632^{bc}	9.5
NDF	661^{a}	557^{b}	602^{b}	593^{b}	12.5
ADF	662^{a}	606^{b}	663^{a}	634^{ab}	11.6
Nitrogen balance (g)					
N intake	92.6^{a}	79.9^{b}	76.8^{c}	80.4^{b}	0.7
N in feces	25.1^{c}	31.3^{a}	26.7^{bc}	29.6^{ab}	0.8
N in urine	3.6^{a}	2.4^{b}	2.4^{b}	2.2^{b}	0.1
N retained	63.9^{a}	46.2^{b}	47.7^{b}	48.5^{b}	0.9

URTRS: urea treated rice straw. SF: supplemental feed. ^{a,b} Mean within rows with different superscripts are significantly different ($P<0.05$)

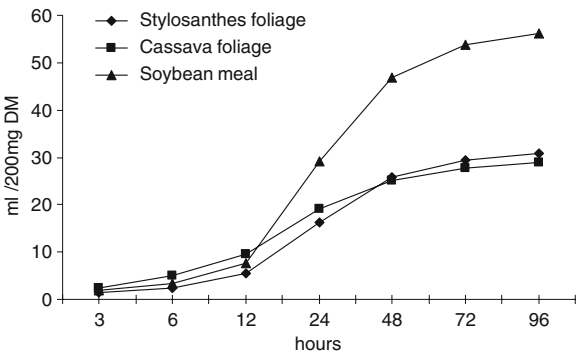

Fig. 2 The gas production during incubation time (ml/200 mg DM)

Effects of supplementation

All animals were offered the same amount of CP from the supplemental feeds. However, the DM intake of URTRS in the control group fed soybean meal was much higher than in the groups supplemented with foliages. This may partly be because the animals fed soybean meal had a lower rumen fill and supplementing a high quality protein like in soybean meal may positively affect the rumen ecosystem and stimulate feed intake (Preston and Leng 1987). This resulted in a higher N intake from URTRS for this group. The tannins tend to affect the nutritive value of ruminant feeds by reducing voluntary feed intake (Barry and McNabb 1999). According to Khang and Wiktorsson

(2006) the use of cassava foliage, which contains tannins, resulted in significantly lower feed intake from fresh urea treated rice straw with increasing levels of cassava foliage in the diet. However, in the present study, the total tannin intake was low, ranging from 22.5 to 33.5 g kg^{-1} DM and a negative effect on the total DM intake could not be observed. At high levels of tannins, 50 to 90 g/kg DM, the digestibility of the fibre in the rumen is reduced (Reed 1995) by inhibiting the activity of bacteria and anaerobic fungi (Chesson et al. 1982). Thang et al. (2008) concluded that the level of tannins when feeding a mixture of cassava and *Phaseolus calcaratus* legume in the concentrate did not affect the total DM intake of cattle.

When the animals were supplemented with a mixture of cassava and stylosanthes foliage, the amount of URTRS consumed was slightly higher than for the groups fed only cassava or stylosanthes. Kiyothong (2003) suggested that offering a combination of cassava and stylosanthes hay slightly affected the by-pass protein supply. The positive or negative effects of secondary compounds depend on the interactions with other nutrients in the diet (Tscherning et al. 2006). The significantly higher apparent OM and CP digestibility in the groups fed stylosanthes foliage or soybean meal compared to those fed only cassava foliage indicates that there was probably an adverse effect of HCN during the experimental period. Moreover, cattle require additional protein and energy to maintain an efficient rumen ecosystem that stimulates nutrient intake and improve animal performance (Preston and Leng 1987). The group fed cassava foliage, in the present study, was offered the feed with the lowest content of OM, resulting in reduced OM intake and a lower NDF digestibility leading to an unbalanced nitrogen/energy ratio and more nitrogen excreted in the faeces.

In the digestibility trial, higher N content in faeces and lower in the urine was observed in the groups fed foliages compared to the group fed soybean meal, resulting in lower N retention. This is in agreement with a recent study by Katongole et al. (2009), who indicated that the increase in faecal N excretion with a decline in urinary N excretion is associated with tannin-protein complexes when goats were fed Leucaena leaves. When expressing N retention as a percentage of N intake, the value ranged from 58 to 69% in the present study, which is high since N retention normally is around 19% of the intake (Hill et al. 2007). According to Slyter et al. (1979) the apparent increase in nitrogen retention can be due to a methodological error in the nitrogen balance technique. This is particularly true for livestock experiments carried out in metabolism cages where urine may be exposed to ureolytic bacteria in steel cages or collection equipment despite the use of preservatives in the urine collection vessel. The result then gives an apparent increase in nitrogen retention (Slyter et al. 1979). Moreover, the URTRS used as basal diet in the present study is also affected by losses of evaporated nitrogen during the feeding for animals. If there is a systematic error in intake of nitrogen, which is over-estimated, and in output of N being under-estimated, the calculated retention become too high.

The LWG of animals observed in the present study was 337 to 477 g day^{-1} when fed foliages. This is comparable to results by Kariuki et al. (1999) where supplementation with lucerne legume hay significantly increased the LWG to 520 g day^{-1}, comparable to a control fed only napier grass (410 g day^{-1}). The authors also indicated that the lucerne supplement improved DM intake, OM intake, CP intake and NDF intake due to increased degradation rate leading to higher concentration of rumen ammonia. The improved levels of rumen ammonia may increase the population of rumen cellulolytic microbes and subsequently improve the digestion (Preston and Leng 1987). The mixture of cassava foliage and legume kept the concentration of tannins to a moderate level and probably affected the protein precipitation prop-

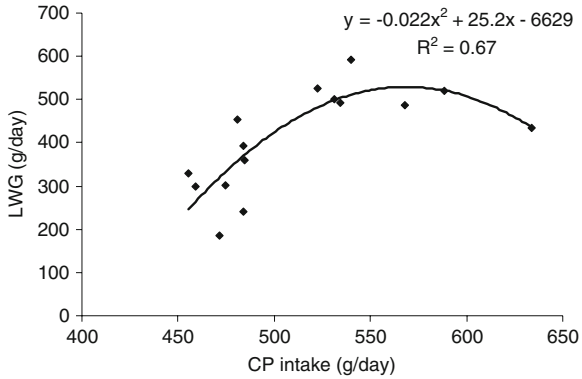

Fig. 3 Relationship between live weight gain and CP intake in the groups fed foliages

erties of the diet in a positive way (Terrill et al. 1992). In the present study, LWG was 30% and 19% higher respectively in the group fed a mixture of foliages as compared with the groups fed cassava or stylosanthes as a sole foliage. The highest LWG of 500 g day^{-1} was obtained with a CP intake of around 560 g day^{-1} in the diet supplemented with foliages (Fig. 3).

Conclusion

The stylosanthes and mixture of cassava and stylosanthes foliage improved DM intake, digestibility and live weight gain of animals fed a basal diet of urea treated rice straw. However, the factors of low OM and high level of HCN in the diet when feeding only cassava foliage might explain the negative effect on intake, NDF digestibility and N retention, and resulted in lower growth rates.

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