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Effect of using cassava products to vary the level of energy and protein in the diet on growth and digestibility in cattle

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ABSTRACT

The effects of feeding different levels of energy and protein using cassava products (*Manihot esculenta* Crantz) (roots and foliage) in the diet on growth rate and diet digestibility were studied in two experiments with growing cattle. In the growth trial, twenty-eight animals were allocated to a completely randomized 2×2 factorial design with seven animals per diet. The four diets consisted of two levels of crude protein (CP) (400 g and 540 g day^{-1}) and two levels of metabolisable energy (ME) (25 MJ and 32 MJ day^{-1}). The diets were formulated based on the nutrient content of cassava foliage, cassava roots, urea and elephant grass. The amount of urea was the same in all diets, 63 g head^{-1} day^{-1}, on DM basis. The digestibility trial was conducted after two months of the growth experiment. The lowest values of OM and GE digestibility were in the group fed the high CP and low ME level, while the group fed the low CP and high ME level had the lowest CP digestibility. There was a significant linear regression between OM digestibility and HCN intake and tannin intake in the groups fed on the low energy level. There was no significant difference in live weight gain between the groups fed either low ME, or high ME and low CP. The highest nutrient digestibilities were found in the group fed both high CP and ME resulting in a significantly higher daily gain, 558 g day^{-1}. In conclusion, an increased level of CP and ME in the diet, achieved using cassava products, improved diet digestibility and growth rate of cattle fed low quality grasses. In order to overcome the negative effect of HCN, cattle fed high amounts of cassava foliage should be supplied with extra energy in the diet.
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1. Introduction

Cassava (*Manihot esculenta*, Crantz) is an annual tuber crop grown widely in the tropical areas of Africa, Asia and Latin America. Cassava tubers contain high levels of energy and have been utilised as a source of readily fermentable energy in ruminant rations (Wanapat, 2003; Promkot and Wanapat, 2005). The level of non-structural carbohydrates (NSC) in cassava meal or chip has been reported as comparable to other energy sources, including corn meal (Sommart et al., 2000; Chanjula et al., 2003). The foliage from cassava has been used as a potential protein supplement for growing cattle (Vongsamphan and Wanapat, 2004; Khampa et al., 2009; Thang et al., 2009). However, when feeding cassava foliage to cattle the energy content became a limiting factor while the crude protein (CP) content in the diet met the requirements, as reported by Wanapat (2008) and Thang et al. (2009). Home-made concentrate containing high levels of cassava chips and cassava hay fed to dairy cows resulted in improved rumen ecology, milk yield and milk composition (Petlum et al., 2004). Khampa and Wanapat (2006) concluded that cassava chip can be used as an energy source in the concentrate at 2% of body weight (BW) (80% of cassava chip in the concentrate) and improved rumen fermentation efficiency in cattle fed urea treated rice straw. The combination of two sources of carbohydrates (maize and molasses) with two CP levels of 150 and 200 g/100 kg live weight (LW)/day (from *Sesbania grandiflora* foliage and urea) led to increased dry matter (DM)

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intake, nitrogen retention and live weight gain (LWG) of cattle fed a basal diet of rice straw and Para grass (Luc et al., 2009). The supplementation of energy and nitrogen simultaneously in cattle resulted in improved microbial efficiency, nutrient utilisation, and animal performance (Kim et al., 1999; Richardson et al., 2003; Hersom, 2008). There are some arguments as to whether the improvement of feed intake and growth is affected by synchronisation between energy and protein sources (Casper et al., 1999; Richardson et al., 2003; Cole and Todd, 2008) or due to some other aspects (Richardson et al., 2003). Shabi et al. (1998) reported that dietary energy supply was more influential than synchrony.

The objective of the present study was to study the effect of different levels of energy (from cassava meal) and protein (from cassava foliage) in the diet on the *in vivo* digestibility and growth rate of growing cattle.

2. Materials and methods

2.1. Location

The experiments were conducted at the YenPhu Dairy and Beef Cattle Breeding Centre in Ninh Binh Province, which is about 120 km southwest of Hanoi. The centre is located in the foothills of the northern MayBac mountains at N20°14 latitude and E105°29 longitude. The climate is tropical monsoon with a wet season from March to October and a dry season from November to February. The average rainfall during 2008 was around 2100 mm. The mean temperature and humidity during the experiments were 13.2 to 28.7 °C and 77.1 to 87.9%, respectively. The study was carried out from March to June 2009.

2.2. Experimental animals

Twenty-eight crossbred growing female cattle (50% local Yellow cattle and 50% Sindhi) (both *Bos indicus*) at around seven months of age with an average live weight of 126.3 kg (SD = 16.6) at the start were used in the experiments. The animals were selected from the herd of the centre 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 live weight (LW)) and were vaccinated against pasteurellosis and two weeks later against Foot and Mouth Disease. The animals were weighed at the end of the adaptation period when the feed intake was stable.

2.3. Experimental feed preparation

The feeds used in the experiments were elephant grass and supplemental feed consisting of cassava foliage, cassava meal and urea. The cassava crops were planted in a nearby experimental site in April 2008. Before planting, manure was applied at the rate of 10,000 kg ha^{-1} on fresh basis. The cassava foliage was harvested the first time three months after planting. At harvesting time the cassava was 110 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 material included whole cassava stem, leaf and petiole. After cutting, the foliage was sun-dried immediately for two to three days to reach a moisture content of less than 12%. The foliage hay was packed in plastic bags. Before the adaptation period the cassava foliages were re-sun-dried for a second time and then ground by a milling machine with 2 mm sieve. The cassava roots were harvested in November 2008. Un-peeled cassava was cut into slices, 1–2 mm thick, sun-dried and ground. During the experimental period the ground cassava foliages and cassava meal were re-sun-dried to prevent mould. The urea with 46% N was bought in a local market. The supplemental feed was made daily by thoroughly mixing the ingredients before feeding.

The re-growth of elephant grass (*Pennisetum purpureum*) at an age of 45 days was harvested daily in the morning. It was chopped by a cutting machine into 5–10 cm lengths before feeding.

2.4. Experimental design and treatments

The cattle were randomly allocated to four treatments in a completely randomized 2×2 factorial design with seven animals in each group. The four diets consisted of two levels of CP (400 g/day and 540 g/day) and two levels of metabolisable energy (ME) (25 MJ/day and 32 MJ/day). The daily rations for the animals are shown in Table 1. The amount of urea was similar in all treatments, 63 g/head/day, on DM basis.

2.5. Feeding and management

The animals were kept 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 supplemental feeds were supplied first in a separate bucket, and then elephant grass was given in a feed trough. 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.

2.6. Data collection

Daily feed consumption was recorded and refusals collected from individual animals in the morning of the next day. The intake of supplemental feeds and elephant grass 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 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

Table 1
Experimental diets (on DM basis).

ME levels	Low energy, 25 MJ/d		High energy, 32 MJ/d	
CP levels (g/d)	400	540	400	540
Elephant grass (kg/d)	1.9	1.8	1.9	1.8
Cassava foliage (kg/d)	0.2	1.2	0.1	1.1
Cassava meal (kg/d)	0.8	0.2	1.4	0.9
Urea (g/d)	63	63	63	63

and final weight. Growth rate was calculated as final weight minus initial weight divided by days in the experiment. During the growth study, the LW was recorded every second week with the same procedure and the data was used to show accumulated growth curves. 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.

In the digestibility study, the faeces from all animals were collected and the weight recorded during five days. The trial was carried out after two months in the growth experiment. The feeds offered and refused were recorded daily from individual animals and weighed before new feed was added. The amount of feeds supplied was equal to 90% of the fresh intake in the week prior to the digestibility trial period. The total amounts of faeces excreted by individual animals were collected and measured daily. During the collection time the faeces was sampled and frozen and stored for future analysis.

The indoor temperature and humidity of the cattle shed were measured three times per day at 07.00 h, 14.00 h and 21.00 h to investigate the effect of the environment on feed intake and performance.

2.7. Chemical analysis

During the growth trial, the feeds offered and individual feed refusals were sampled daily and pooled to one sample for two weeks. During the digestibility period, the feeds offered and refused and faeces were sampled daily and then pooled for the five days collection period. Samples of feeds, refusals and faeces were analysed for DM, ash, CP, ether extract (EE), neutral detergent fiber (NDF), and acid detergent fiber (ADF). Cassava foliage and cassava meal were also analysed for total tannins and HCN. 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).

Table 2
Chemical composition and estimated ME content of the experimental feeds (mean and S.D.).[a]

Item	Elephant grass	Cassava foliage	Cassava meal	Urea
DM (g/kg)	205 (12.9)	907 (7.2)	874 (12.7)	900 (0.2)
In g/kg DM				
OM	922 (13.8)	889 (4.3)	984 (1.0)	NA[b]
CP	88 (13.4)	168 (9.9)	28 (12.6)	2870 (4.8)
EE	14 (2.3)	32 (3.3)	3.9 (0.6)	NA
NDF	755 (47.8)	460 (36.5)	75 (9.4)	NA
ADF	454 (16.6)	310 (12.4)	50 (4.8)	NA
Tannins	NA	12 (1.6)	1.9 (0.4)	NA
HCN[c] (mg/kg)	NA	184 (52.5)	55 (15.9)	NA
Converted by value of gross energy				
ME[d] (MJ kg/DM)	7.6 (0.8)	7.9 (0.3)	12.6 (0.9)	NA

[a] $N=6$.
[b] NA: not analysed.
[c] HCN: hydrogen cyanide.
[d] ME: metabolisable energy (MJ/kg DM).

The ME values of the feeds were calculated based on data of gross energy (GE) and *in vitro* OM digestibility (ivOMD). The ME was assumed to be 82% of the digestible energy (DE) (MAFF et al., 1984; Robinson et al., 2004) as ME (MJ/kg DM) = 0.82 × (GE × ivOMD), where GE (MJ/kg DM) was measured by bomb calorimetry and ivOMD was measured by the rumen fluid-based method described by Tilley and Terry (1963).

2.8. Statistical analysis

The data were analysed statistically by ANOVA using the general linear model 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 was $Y_{ij}=\mu+\alpha+\beta_j+(\alpha\beta)_{ij}+\varepsilon_{ij}$ where: Y_{ij} is the dependent variable, μ is the overall mean, α_i is the effect of protein level *i*, β_j is the effect of energy level *j*, $(\alpha\beta)_{ij}$ is the effect of interaction protein energy, and ε_{ij} is the random error. Nutrient intake, LWG and FCR were tested with the initial weight, ambient temperature and humidity as covariates in the statistical model, but since the covariates were not significant ($P>0.05$) they were omitted from the final model.

3. Results

3.1. Growth experiment

Table 2 shows the chemical composition of cassava foliage, cassava meal and elephant grass. The cassava foliage contained 168 g CP kg^{-1} DM and CP contents of the elephant grass and the cassava meal were 88 g kg^{-1} DM and 28 g kg^{-1} DM, respectively. NDF and ADF contents of elephant grass were high (755 g kg^{-1} DM and 454 g kg^{-1} DM, respectively). The cassava foliage had a high level of HCN (184 mg kg^{-1} DM). The total tannin content was 12 and 1.9 g kg^{-1} DM in cassava foliage and cassava meal, respectively.

Mean values of feed consumed for the different diets are presented in Table 3. There were no interactions between level of protein and energy in the diets in relation to daily nutrient intake except for EE g^{-1} day and HCN mg per kg BW, and DMI expressed as % of BW or per kg metabolic BW. The total DM intake (DMI) in kg per day was lowest for the group fed a combination of low ME and low CP. When expressed relative to metabolic BW, there were no significant differences in DMI among groups fed high ME and/or CP. A significantly higher tannin and HCN consumption was recorded in the groups fed the high level of cassava foliage.

The effect of feeding different levels of protein and energy on the LWG is shown in Table 4. The LWG was significantly higher in the group fed both high ME and CP than for the groups given a low ME and/or CP level. The lowest efficiency of feed utilisation (FCR) was observed in the group fed the low ME and high CP level. The accumulated live weight of the animals during the experiment is shown in Fig. 1.

3.2. Digestibility experiment

Daily feed intake and apparent digestibility are reported in Table 5. The OM and HCN intakes were significantly higher at high ME and/or CP than for the group fed both low ME and CP.

Table 3
Feed and nutrient intake (LS means).

ME levels	Low energy, 25 MJ/d		High energy, 32 MJ/d		SEM [1]	Significance level [2]		
CP levels	400	540	400	540		CP	ME	CP*ME
DM intake (g/d)	2889^{c}	3238^{b}	3289^{b}	3644^{a}	36.3	***	***	NS
DMI in % of BW	2.1^{b}	2.3^{a}	2.5^{a}	2.4^{a}	0.06	NS	**	*
DMI in g/kg $W^{0.75}$	71^{b}	80^{a}	83^{a}	85^{a}	1.3	**	***	*
Nutrient intake								
OM (g/d)	2703^{d}	2961^{c}	3102^{b}	3370^{a}	34.1	***	***	NS
EE (g/d)	37.3^{b}	65.1^{a}	38.3^{b}	63.7^{a}	0.5	***	NS	*
NDF (g/d)	1588^{b}	1986^{a}	1568^{b}	1890^{a}	27.9	***	NS	NS
ADF (g/d)	968^{b}	1236^{a}	959^{b}	1181^{a}	16.5	***	NS	NS
Tannins (g/d)	4.5^{c}	14.7^{a}	5.4^{b}	15.2^{a}	0.1	***	***	NS
HCN (mg/d)	86^{d}	225^{b}	110^{c}	247^{a}	2.2	***	***	NS
HCN (mg/kg BW)	0.6^{c}	1.6^{a}	0.8^{b}	1.6^{a}	0.02	***	**	**

[a,b,c,d] Mean within rows with different superscripts are significantly different ($P<0.05$).
[1] SEM: standard error of means.
[2] NS: none significant.
* $P<0.05$.
** $P<0.01$.
*** $P<0.001$.

There was a significant linear regression between OM digestibility and HCN intake and tannin intake in the groups fed the low energy level (Figs. 2, 3), while in the groups fed the high energy level the regressions were not significant. The highest nutrients digestibility was in the group fed both high ME and CP. Groups fed high energy had significantly higher digestibility of OM and GE than groups fed low energy. The lowest digestibility of OM and GE was for group fed the low energy and high protein level. The lowest CP digestibility was recorded in the group fed high ME and low CP.

4. Discussion

4.1. Characteristics of the supplemental protein and energy sources

A lower CP content of the cassava foliage was observed as compared to values reported by Phengvichith and Ledin (2007) and Wanapat (2008), but was similar to Thang et al. (2009). The content of CP depends on the proportion of leaves and stem, soil fertility and harvesting time. The cassava foliage used in the experiment contained stems, petioles and leaf, which may explain the lower CP content. The concentration of HCN in the cassava foliage (184 mg kg^{-1} DM) 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 the cassava variety (Tewe and Lyayi, 1989). The processing to hay (i.e. chopping and sun drying) can reduce the content of HCN in the cassava foliage by 35% (Phengvichith and Ledin, 2007), or even to 63% of the initial fresh value as reported by Khieu Borin et al. (2005). In cattle and sheep, HCN can be lethal at 2 to 4 mg HCN kg^{-1} LW (Kumar, 1992). On the diet with the highest intake of HCN, the animals consumed 1.6 mg kg^{-1} LW, which was below the lethal dose stated above. There were no apparent symptoms of HCN toxicity in the animals consuming cassava foliage.

The low CP content of the cassava meal, 28 g kg^{-1} DM, is within the range of values reported in the literature, of 10 to 35 g kg^{-1} DM (Muzanila et al., 2000; Chanjula et al., 2003). The dried cassava root has a high energy content due to the high content of starch (Muzanila et al., 2000) which provides readily available carbohydrates for fermentation in the rumen. According to Chanjula et al. (2003) the starch in the cassava meal has a high degradability in the rumen which

Table 4
Weight gain and feed conversion ratio (LS means).

ME levels	Low energy, 25 MJ/d		High energy, 32 MJ/d		SEM [1]	Significance level [2]		
CP levels	400	540	400	540		CP	ME	CP*ME
Initial weight (kg)	126	126	122	127	1.7	NS	NS	NS
Final weight (kg)	157	158	154	179	3.5	*	**	**
LWG (g/d)	344^{b}	308^{b}	400^{b}	577^{a}	26.5	*	***	**
FCR (kg DM/kg LWG)	8.7^{ab}	10.9^{a}	8.5^{ab}	6.4^{b}	0.7	NS	**	*
FCR (kg CP/kg LWG)	1.2^{b}	1.8^{a}	1.0^{b}	0.9^{b}	0.1	*	***	**
FCR (MJ ME/kg LWG)	80^{ab}	85^{a}	76^{ab}	58^{b}	6.0	NS	*	NS

[a,b] Mean within rows with different superscripts are significantly different ($P<0.05$).
[1] SEM: standard error of means.
[2] NS: none significant.
* $P<0.05$.
** $P<0.01$.
*** $P<0.001$.

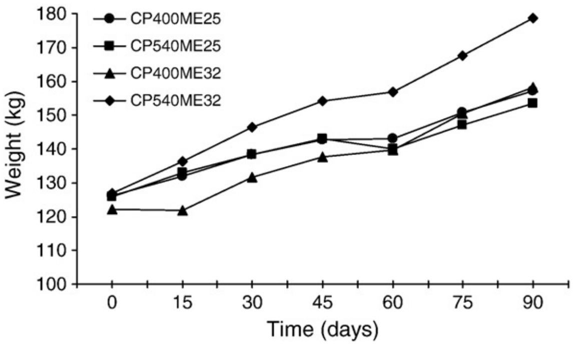

Fig. 1. Accumulated live weight of the animals during the experiment.

potentially facilitated the achievement of optimal energy to protein ratio.

4.2. Effect of dietary protein and energy supply

In the growth experiment, both cassava foliage and cassava meal were almost completely consumed. Feeding higher levels of nutrients lead to increasing total DM feed intake ($P<0.05$) and probably resulted in a better match between animal requirement and dietary supply (Schroeder and Titgemeyer, 2008). The supply of both nitrogen and readily available carbohydrates probably improved the rate of degradation of the diet, microbial growth and the fractional outflow of liquid matter from the rumen (Shem et al., 2003; Baumann et al., 2004). However, the effects of energy and protein supply on intake and digestibility may be different, depending on the amount of nutrients delivered to the animal. In the present study, an improvement of apparent digestibility coefficients of OM, GE, NDF and ADF was observed in the cattle fed the high energy diet (32 MJ day^{-1}) as compared to the low level (25 MJ day^{-1}). In contrast, Klevesahl et al. (2003) observed no increases in NDF and ADF digestibility when beef steers were fed a high level of energy with corn starch, arguing that the rapid fermentation of starch resulted in decreasing fiber digestion in the rumen, related to low ruminal pH. However, the rate and extent of ruminal fermentation vary widely and digestion depends on the type of grain and degree of processing (Chanjula et al., 2003). The low digestibility of fiber could also be due to the low quality of the fiber in the diet. One strategy for using highly degradable carbohydrates is to use them in combination with readily available NPN sources such as urea (Wohlt et al., 1978; Khampa et al., 2009). In the study 63 g day^{-1} of urea was used for supplying N in the diets and to balance ruminal pH when feeding high amounts of starch. At the low level of energy supply (25 MJ day^{-1}), increasing the level of protein (540 g day^{-1} CP) in the diet resulted in the lowest OM, GE and ADF digestibility. The results indicate that increasing the protein level did not improve nutrient utilisation when energy intake was limiting. According to the theory of protein- and energy-dependent phases of growth, the output from protein intake depends on the level of energy supplied (Chowdhury and Ørskov, 1997; Titgemeyer, 2003) and this theory seems to support the result in this study. The animal is not responding or responds only with a very low efficiency to additional increases in protein supply when energy intake becomes a limiting factor (Schroeder and Titgemeyer, 2008). However, there are some arguments that the endogenous energy mobilisation (i.e. body fat) can be used as fuel at negative energy balance to sustain protein accretion (Vipond et al., 1989; Chowdhury et al., 1991). Furthermore, Iason and Mantecon (1993) and Chowdhury and Ørskov (1997)

Table 5
DM intake, nutrient intake, and apparent digestibility in the digestibility experiment.

ME levels	Low energy, 25 MJ/d		High energy, 32 MJ/d		SEM [1]	Significance level [2]		
CP levels	400	540	400	540		CP	ME	CP ME
DM intake (g/d)								
DMI of grass	1607^{b}	1754^{a}	1701^{a}	1573^{b}	20.7	NS	*	***
DMI of SF [3]	962^{c}	1230^{b}	1324^{b}	1798^{a}	27.4	***	***	***
Total	2569^{c}	2984^{b}	3025^{b}	3371^{a}	33.8	***	***	*NS*
Nutrient intake								
OM (g/d)	2449^{d}	2777^{c}	2904^{b}	3160^{a}	30.1	***	***	NS
CP/ME	15.7^{b}	21.4^{a}	12.6^{c}	16.9^{b}	0.05	***	***	**
EE (g/d)	28.7^{b}	55.8^{a}	30.5^{b}	55.0^{a}	0.6	***	NS	*
NDF (g/d)	1473^{d}	1938^{a}	1568^{c}	1828^{b}	19.4	***	NS	***
ADF (g/d)	874^{d}	1165^{a}	926^{c}	1105^{b}	12.2	***	NS	***
Tannins (g/d)	5.3^{c}	16.4^{b}	5.9^{c}	17.6^{a}	0.3	***	**	NS
HCN (mg/d)	111^{d}	315^{b}	146^{c}	341^{a}	6.3	***	***	NS
Digestibility (/kg DM)								
OM (g)	644^{b}	587^{c}	696^{a}	709^{a}	10.1	*	***	**
CP (g)	684^{bc}	697^{b}	652^{c}	741^{a}	9.4	***	NS	***
GE (MJ)	596^{b}	546^{c}	653^{a}	673^{a}	11.3	NS	***	**
EE (g)	341^{b}	389^{b}	371^{b}	476^{a}	19.6	***	**	NS
NDF (g)	536^{b}	542^{b}	567^{ab}	607^{a}	12.9	NS	***	NS
ADF (g)	529^{ab}	484^{b}	574^{a}	554^{a}	14.4	*	***	NS

[a,b,c,d]Mean within rows with different superscripts are significantly different ($P<0.05$).
[1] SEM: standard error of means.
[2] NS: none significant.
[3] SF: supplemental feed.
* $P<0.05$.
** $P<0.01$.
*** $P<0.001$.

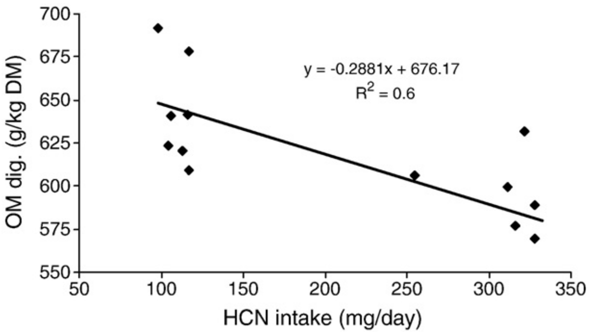

Fig. 2. Regression between OM digestibility and HCN intake in groups fed on a low energy level.

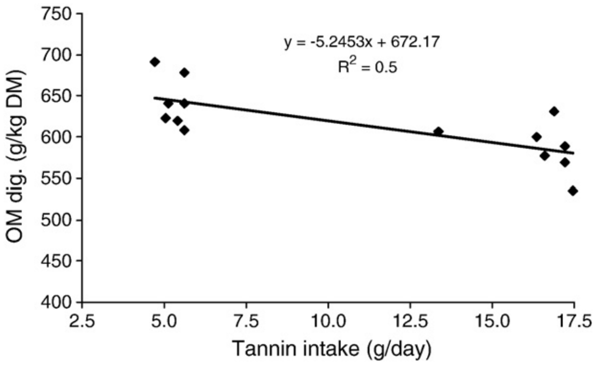

Fig. 3. Regression between OM digestibility and tannin intake in groups fed on a low energy level.

assumed that adipose tissue mobilisation is used to provide energy for protein deposition only when animals have excess fat and there is an adequate protein supply. The animals in the present study were not fat and any endogenous energy mobilisation could not be expected. When feeding cassava foliage to cattle, the negative effects of HCN concentration as an antinutritive factor on feed intake and digestibility has been shown by Wanapat (2003) and Khang and Wiktorsson (2006). In a recent study, Thang et al. (2009) reported that there was significantly lower apparent OM and CP digestibility in the groups fed only cassava foliage compared to those fed stylosanthes foliage or soybean meal, implying a probable adverse effect of HCN. The positive or negative effects of secondary compounds depend on the interactions with other nutrients in the diet (Tscherning et al., 2006). With a low dietary energy supply, the higher HCN and tannin intake achieved by increasing cassava foliage supply in the diet might be one of the reasons for the lower OM digestibility (Figs. 2, 3).

In this study, the cattle were fed diets with levels of protein and energy at or below the estimated protein and energy requirement for tropical cattle with a LWG of 500 g day^{-1}, as recommended by Kearl (1982). The LWG of the animals ranged between 308 and 558 g day^{-1}. A similar result, 233 g to 337 g day^{-1}, was reported by Khang and Wiktorsson (2006) and Thang et al. (2009) when F1 crossbred cattle were fed cassava foliage. Increasing both the level of energy and protein in the diet increased the LWG of the animals. In the study, LWG was about 25–45% lower in the cattle fed at low protein and/or energy as compared with the cattle fed both high protein and energy. The lowest growth rate was observed in the group fed low energy and with a high HCN intake. Tewe (1983) reported that feeding a basal diet of cassava foliage resulted in high HCN ingestion, leading to reduced growth rate in sheep and goats. When feeding a sub-lethal dose of HCN, the detoxification process can occur via many pathways, but the most important is the reaction of cyanide with thiosulphate to form thiocyanate and sulphite. The thiocyanate is not only a cause of depletion of sulphur containing amino acids by urinary excretion, but also inhibits the intra-thyroidal uptake of iodine, leading to an increase in secretion of thyroid stimulating hormone, and causes a reduction in thyroxine level, which is necessary for growth (Tewe, 1992). The use of vegetable oil improved the growth rate of local Yellow cattle when supplementing cassava foliage to a basal diet of rice straw (Mom Seng et al., 2001). Fomunyam et al. (1980) also reported that the toxic effect of HCN in cassava was greatly reduced in the presence of palm oil. It was suggested that this occurs because the supplemental oil delays the decomposition and therefore prevents the absorption of the cyanogenic glucosides (Fomunyam et al., 1980; Tewe, 1992). However, the question is still open as to whether there is an effect of energy level in the diet on metabolic detoxification in cattle or not. But it is obvious that the ingestion of HCN resulted in no negative effect on digestibility and growth rate in the group fed high energy.

5. Conclusion

Increasing the level of CP and ME in the diet using cassava products improved the digestibility and growth rate of cattle fed low quality grasses. Supplying extra energy in the diet for cattle fed a high amount of cassava foliage might be necessary to overcome the negative effect of HCN.

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