ORIGINAL ARTICLE

Effects of varieties and timing of subsequent cutting on yield, chemical composition and ruminal degradability of cassava Hay in Southern Thailand

Pin Chanjula[1] and Somnuek Sornnok[2]

Abstract

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A 2x2 factorial arrangement in a randomized complete block design with 4 replications was carried out to investigate the effects of varieties (V, KU50 and RY72) and timing of subsequent cutting (SC, 2 and 3 months after cutting) on yield and chemical composition of cassava hay. The results revealed that both total hay yield and crude protein dry matter yield were not significantly (P>0.05) influenced by variety or subsequent cutting. Cassava could produce from 4.98 to 6.15 t/ha of DM and 1.29 to 1.39 t/ha of CP. CP content in cassava plant ranged from 23.03 to 26.55% and was affected by different SC regimes. Their DM and CP rate of degradability of cassava hay (CH) were studied using the nylon bag technique, in ruminally fistulated crossbred

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beef steers. The ruminal disappearance characteristics of CH and the effective degradability of DM and CP of all treatments were not significantly different (P>0.05) among the treatments. Based on this research, it was concluded that two varieties with subsequent cutting at 2 or 3 months intervals for 9 months was optimal to obtain high dry matter and protein yield as well as moderate-high nutritive value cassava hay. Moreover, it could be cultivated to produce CH with high nutritive value in southern conditions.

Key Words: cassava hay, varieties, subsequent cutting, ruminal degradability, yield and chemical compositions.

บทคัดย่อ

ปิ่น จันจุฬา และ สมนึก สอนนอก

ผลของพันธุ์และระยะเวลาในการตัดต่อเนื่องต่อผลผลิตและองค์ประกอบทางเคมีของมันเฮย์ในภาคใต้ของประเทศไทย

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ทำการศึกษาถึงผลของพันธุ์และระยะเวลาในการตัดต่อเนื่องต่อผลผลิต และองค์ประกอบทางเคมีของมันเฮย์ โดยใช้แผนการทดลอง 2x2 แฟกทอเรียลในบล็อกสมบรูณ์ โดยมี 4 ซ้ำด้วยกัน จากการทดลองพบว่า ผลผลิตน้ำหนักแห้งและโปรตีนทั้งหมดมีค่าไม่แตกต่างกันทางสถิติ (P>0.05) ผลผลิตน้ำหนักแห้งของมันเฮย์ที่ได้อยู่ในช่วง 4.98-6.15 ตัน/เฮกแตร์ และผลผลิตโปรตีนทั้งหมดเท่ากับ 1.29-1.39 ตัน/เฮกแตร์ ส่วนค่าโปรตีนหยาบอยู่ในช่วง 23.03-26.55% และระยะเวลาในการตัดมีผลต่อค่าโปรตีนหยาบ การศึกษาความสามารถในการย่อยสลายได้ในกระเพาะรูเมนของมันเฮย์ โดยใช้เทคนิคถุงไนล่อนทดลองในโคเนื้อลูกผสมที่ได้รับการเจาะกระเพาะรูเมนแบบถาวร พบว่าค่าการย่อยได้และค่าประสิทธิภาพในการย่อยสลายได้ ของวัตถุแห้งและโปรตีนของมันเฮย์ไม่แตกต่างกันทางสถิติ (P>0.05) ในการทดลองครั้งนี้ พบว่า มันสำปะหลังทั้ง 2 พันธุ์และระยะเวลาในการตัดต่อเนื่องทุก ๆ 2 หรือ 3 เดือน เป็นเวลา 9 เดือน มีความเหมาะสมต่อการปลูกมันสำปะหลังเพื่อผลิตมันเฮย์ เนื่องจากให้ผลผลิตน้ำหนักแห้งและผลผลิตโปรตีนในระดับสูงมากกว่านั้นสามารถปลูกมันสำปะหลังเพื่อผลิตมันเฮย์ที่มีคุณค่าทางโภชนะสูงได้ในพื้นที่ภาคใต้

ภาควิชาเทคโนโลยีและการอุตสาหกรรม คณะวิทยาศาสตร์และเทคโนโลยี มหาวิทยาลัยสงขลานครินทร์ วิทยาเขตปัตตานี จังหวัดปัตตานี 94000

Cassava or tapioca (*Manihot esculenta*, Crantz) is an annual tropical tuber crop grown widely in tropical and sub-tropical countries (Calpe, 1992). This plant is well known and easily grown under minimal management and is adaptable to poor soil condition,low rainfall and high temperature and has good pest tolerance. In Thailand, cassava is one of the most important economic crops and it also has been regarded as a cash crop. It is produced by small-holder farmers on marginal land.Usually,cassava is grown for root production as energy sources. Cassava leaf or whole cassava crop, collected as a crop-residue at annual tuber harvesting time has been sun-dried and used as a protein sources for animal feed (Ravindran,1993), especially dairy cattle (Wanapat *et al*.,1997; 2003). Cassava cultivated for cassava biomass to produce hay is based on cultivated a first harvest of foliage at three months after planting and followed every two or three months thereafter until one year, produced a collective DM hay yield of 11.8 t/ha (Wanapat *et al*.,2002). However, the suitable varieties and har-vesting time of cassava foliage to making hay has not been fully studied especially under southern conditions.

The objective of this experiment is to study the effect of variety and timing of subsequent cutting on hay yield and chemical composition of cassava in the south of Thailand.

Materials and Methods

Experiment 1

Effects of varieties and timing of subsequent cutting on yield and nutritive value of cassava hay (CH).

Experimental location and condition of the study site

The experiment was conducted at the research station, Department of Technology and Industries, Faculty of Science and Technology, Prince of Songkla University, Pattani campus, in the south of Thailand, (06°N, 101°E; 4.05 m above sea level) under rainfed conditions during May 2004 March 2005. The monthly weather data of rainfall, average maximum and minimum temperatures throughout the growing season are shown in Figure 1. The experiment was carried out during May, 2001 to February, 2005 on grey sandy clay soil. The soil conditions of the study site were 5.5 for pH, (H_2O, at the dilution rate of 5), 0.15 for total N%, 54.6 ppm for available P, 258.06 ppm for K_2O, 246.10 ppm for Na, 1.62 (ms 25 °C) for EC and 1.81% for OM.

Experimental design and treatments

The experimental layout was a 2x2 factorial arrangement in a randomized complete block design (RCBD) with four replications to study the effects of different cassava varieties and timing of subsequent cutting on yield and chemical compositions of cassava crop.The experiment consisted of 2 factors, factor A and factor B.

Factor A, included 2 different cassava varieties, KU50 and RY72.

Factor B, consisted of 2 different subsequent cuttings at 2 month and 3 months after first cutting at three months.

The experiment consisted of four following treatment combinations:

Treatment 1 ($T1_{KU50-S2}$):KU50 and subsequent cutting at 2 months.

Treatment 2 ($T2_{KU50-S3}$): KU50 and subsequent cutting at 3 months.

Treatment 3 ($T3_{RY72-S2}$): RY72 and subsequent cutting at 2 months.

Treatment 4 ($T4_{RY72-S3}$): RY72 and subsequent cutting at 3 months.

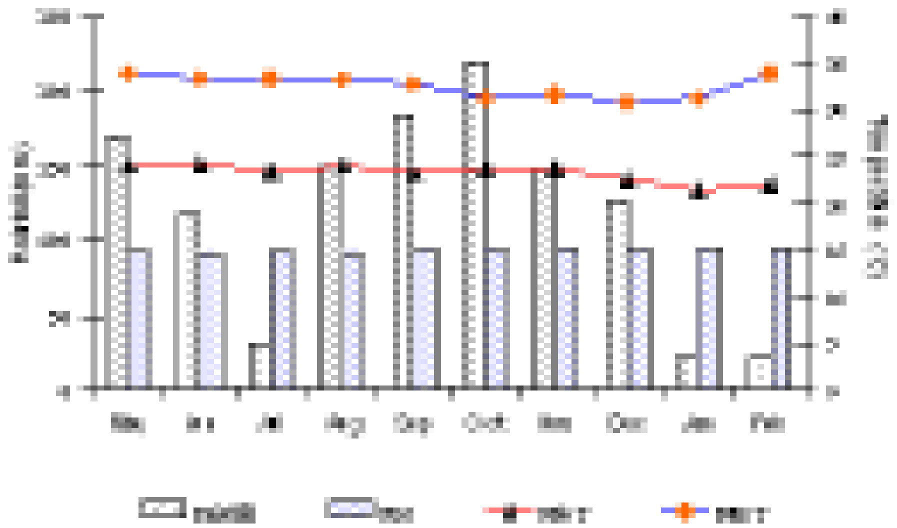

Figure 1. Monthly weather data during the experimental period : rainfall is shown by the columns; RH = relation humidity; Min T = minimum temperature; Max T=maximum temperature. Source:Pattani Meterological Station, (2005).
[Color figure can be viewed in the electronic version]

Land preparation and cassava cultivation

Soil was ploughed once by small tractor without harrowing, weed roots removed and the land divided into 16 plots. Individual plot size was 5x5 m. Cassava was planted in rows using stems as planting material and a 60x40 cm spacing between rows in all plots. Two weeks prior to planting, manure was applied at the rate of 625 kg/ha. All plots the received a basal dressing compound N-P-K fertilizer (15-15-15, respectively) at the rate of 312.5 kg/ha. The entire plot area was kept weed free with hand hoeing at 21 and 56 days after planting and whenever necessary.

Data collection, plant harvesting and determination of yeilds and chemical compositions

After planting, whole crop cassava was harvested a first cutting at 3 months (August, 19, 2004). Approximately at 9-9.30 a.m. of the sampling day (when cassava leaves are free from dew), cassava in the plot was harvested individually according to respective treatments by breaking the stem at approximately 10 cm above ground level in accordance with Wanapat *et al.* (1997) and Wanapat (2003) and then followed by the respective treatments until up to 9 months. All cassava foliage from each plot, which included leaf, petiole and stem material, were weighed and then separated to determine the fresh yield. A sub-sample of approximately 500 g was collected from each plot and dried in a forced-air oven (60 ^{o}C) for 48 h to determine dry matter (DM), which was used to calculate DM yield. Subsamples were prepared for quality analysis by grinding with a Wilely mill to pass through a 1 mm screen for further analysis. DM, CP, CF and total ash were analyzed by the procedure of AOAC (1990). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed by the method of Van Soest *et al.* (1991). Total condensed tannin content was analyzed by the method of Burns (1971).

Experiment 2: Effects of varieties and timing of subsequent cutting on ruminal degradability of cassava hay.

Sample preparation

As mentioned earlier, CH was harvested according to respective treatments ($T1_{KU50-S2}$, $T2_{KU50-S3}$, $T3_{RY72-S2}$, and $T4_{RY72-S3}$). All samples were ground to pass a 2-mm screen and stored for further chemical analysis and degradability study.

Animals and diets

Three ruminally fistulated crossbred beef steers (35±10 kg BW) were used as replicates to determine in situ DM and CP degradabilities of CH. All steers were drenched for internal worms Ivermectin (IDECTIN®) and injected with vitamins A, D_3 and E prior to commencing the experiment. Steers were housed in individual pens and fed 2% BW comprising 70% fresh ruzi grass and 30% concentrate feed (on DM basis) (Table 1). In addition, CH was supplemented at 0.25 kg/hd/d as a roughage source. The diets were offered in two equal meals at 0800 and 1600 h. A 15- day period of adaptation was allowed. Animals had free access to water and trace mineralized salt.

Table 1. Ingredients and chemical composition of the diet consumed by ruminally fistulated crossbred beef steers used for the in situ trials (% of DM basis).

Ingredient	% DM basis
Cassava chip, CC	50.0
Palm cake kernel, PCK	10.0
Soybean meal, SM	4.9
Rice bran meal, RBM	20.0
Broken rice, BR	10.1
Urea	2.0
Molasses	1.0
Minerals and vitamins [1]	1.0
Salt	1.0
Estimated values (total diet)[2]	
DM, %	89.8
CP, %	14.0
TDN, %	77.6

[1]Minerals and vitamins (each kg contains): Vitamin A: 10,000,000 IU; Vitamin E: 70,000 IU; Vitamin D: 1,600,000 IU; Fe: 50g; Zn: 40g; Mn: 40g; Co: 0.1g; Cu: 10g; Se: 0.1g; I: 0.5g.

[2]DM = dry matter, CP = Crude protein, TDN = Total digestible nutrient.

Ruminal disappearance study

In sacco degradability of CH was determined by the nylon bag technique (Ørskov and McDonald, 1979). Bags were made of dacron cloth (7x14 cm) with an approximate pore size of 38 - µm. Approximately 6.0 g of feed samples were weighed into a previously dried (60°C) and tared bag. Bags were tied to a weighed chain and placed in the ventral rumen sac of steers approximately 2 h after the morning feeding. All feeds were incubated simultaneously in both steers using duplicate bags per feed at each time point and a blank bag containing no sample for each removal time. Bags for each feed were removed after 4, 8, 12, 24, 48 and 78 h of incubation. Immediately after removal from the rumen, bags were washed with cold tap water until rinsed the water was clear. Bags were dried for 72 h at 60°C in a forced air oven. The bags were weighed and residues were removed and then analyzed for DM and CP. All bags of feed samples were collected for their corresponding blank. The 0 hour incubation samples were washed and dried in similar condition. The bags were weighed and tested according to the procedure described by Ørskov and McDonald (1979). Samples of rumen fluid were taken through the ruminal canulae at 4, 8, 12, 24, 48 and 78 h of incubation. At each time pH and temperature were measured immediately using a portable pH and temperature meter (Orin Research portable meter 200 series, USA).

Statistical analysis

Data were statistically analyzed using General Linear Model Procedure of SAS (1990). Treatment means were statistically compared using Duncan's multiple range test (DMRT) (Steel and Torrie, 1980). Data were analyzed using the model $Y_{ijk} = \mu + B_i + \alpha_j + B_k + \alpha ß_{jk} + E_{ijk}$. Where Y_{ijk} = observation from treatment, μ =overall mean; B_i= block effect; α_j=effect of varieties; $ß_k$=effect ofsubsequent cutting; $\alpha ß_{jk}$= effect of interaction of varieties and subsequent cutting; E_{ijk}= error of the term.

Data for ruminal disappearance characteristics of DM and CP were fitted to an exponential equation following the procedure described by Ørskov and McDonald (1979) and using the NEWAY program (Chen, 1996).

$$\mathbf{P = a+b(1-e^{-ct})}$$

where,
P = disappearance rate at time t (%),
a = the intercept of the degradation curve at time zero (%),
b = the fraction of DM and CP which will be degraded when given sufficient time for digestion in the rumen (%),
c = a rate constant of disappearance of fraction b (h^{-1}), and
t = time of incubation (h).

The effective degradability (ED) of DM and CP were, therefore, calculated using the following equation.

$$\mathbf{ED = a+b(c/(c+k))}$$

where k assuming the rate of particulate outflow from the rumen, k, is 0.05 h^{-1} by equation of Ørskov and McDonald (1979).

Analysis of variance (ANOVA) for a randomized complete block design (RBCD) (Steel and Torries,1980) was performed on the data in the same incubation time as a separate set following the ANOVA procedure of SAS (1990).

$$\textbf{Model} = Y_{ij} = \mu + \delta_{ij} + \tau_j + \varepsilon_{ij}$$

where Y_{ij} = observation in block of each time, μ = overall mean, δ_i = block effect (time), and τ_j = feed sources, ε_{ij} = residual.

Results and Discussion

Cassava hay yield and chemical composition

Total yield, both fresh, DM and protein yields of cassava at different varieties and timing of subsequent cuttings are presented in Table 2. Biomass yield in terms of fresh, dry matter and protien yields were not affected by variety or sequent cutting, but the stem yield was higher for subsequent cuttings

Table 2. Effects of breed varieties and subsequent cutting on fresh dry fodder and protein yield of cassava hay (t/ha).

Item	KU50		RY72		SEM	Contrast		
	$T1_{VKU50\text{-}S2}$ [2/]	$T2_{VKU50\text{-}S3}$	$T3_{VRY72\text{-}S2}$	$T4_{VRY72\text{-}S3}$		V1/	SC	VS
Fresh yield, t/ha								
Total	27.59	30.76	29.08	28.68	1.29	NS	NS	NS
Leaf	12.96	13.79	13.56	12.67	0.87	NS	NS	NS
Petiole	7.60	6.29	7.85	5.57	0.78	NS	NS	NS
Tenderstem, TS	7.03a	10.68b	7.66a	10.44b	1.12	NS	*	NS
Dry matter yield, t/ha								
Total	4.98	6.15	5.53	5.48	0.56	NS	NS	NS
Leaf, L	2.99	3.27	3.18	2.97	0.42	NS	NS	NS
Petiole, P	1.01	1.17	1.19	0.85	0.34	NS	NS	NS
Tenderstem, TS	0.98a	1.70b	1.16a	1.66b	0.21	NS	*	NS
Crude protein	1.31	1.39	1.35	1.29	0.28	NS	NS	NS

[a-c] **Means with different superscripts in the same row are significantly different (P<0.05).**
SEM = Standard error of the mean (n=4)
***, ** = Significant at 0.05 and 0.001 probability level, respectively, NS = Non significant (P>0.05).**
[1/] **V = Varieties, SC = Subsequent cutting, VS = Interaction between V and SC.**
[2/] **$T1_{VKU50\text{-}S2}$ = KU50 and SC = 2 month; $T2_{VKU50\text{-}S3}$ = KU50 and SC = 3 months; $T3_{VRY72\text{-}S2}$ = RY72 and SC = 2 month; and $T4_{VRY72\text{-}S3}$ = RY72 and SC = 3 months.**

of 3 months compared with 2 months. Dry matter production (in 9 months after planting) ranged from 4.98 to 6.15 t/ha. These data are in agreement with those previously reported Poungchompu *et al.* (2001) and Hong *et al.* (2003), but higher than those obtained by Tung *et al.* (2001) and Petlum *et al.* (2001) Nevertheless, the differences among these studies might be due to the differeent study site, cutting schedule, planting pattern, planting space and density (Gomez and Valdivieso,1984; Poungchompu *et al.*,2001; Petlum *et al.*,2001; Wanapat, 2003)

Protein yield in this study ranged from 1.29 to 1.39 t/ha for four collective harvests. These data are in accordance with those reported by Hong *et al.*(2003), but lower than the levels reported by Wanapat *et al.* (2002) who has reported that protein yield ranged from 1.5-1.7 t/ha for six collective harvests. The differences of protein yield between the two studies were associated with DM and CP values (Table 2). Protein yield of 1.35 t/ha in KU_{50} variety was dramatically higher than that in RY_{72} (1.32 t/ha).

The chemical composition of cassava hay is presented in Table 3. It appeared that chemical composition of CH in terms of DM, Ash, CP, CF, NDF, ADF and ADL was significantly different depending on time of subsequent cutting. The DM values were similar to the value of 18-19% obtained by Moore and Cock (1985) and Hong *et al.* (2003). Variations in fiber components of CH were CF (18.59 to 22.17%), NDF (46.30 to 48.90%), ADF (26.10 to 28.40%) and ADL (11.70 to 13.60 %) and were higher in subsequent cuttings of 3 months.

Table 3. Effects of breed varieties and subsequent cutting on chemical composition of cassava hay.

Item	KU50		RY72		SEM	Contrast		
	$T1_{VKU50-S2}$ [2/]	$T2_{VKU50-S3}$	$T3_{VRY72-S2}$	$T4_{VRY72-S3}$		V[1/]	SC	VS
Chemical composition,%								
DM	17.87a	19.67 b	18.02 a	19.18 b	0.32	NS	**	NS
OM	90.32 a	90.22 b	90.35 a	89.40 b	0.24	NS	*	NS
Ash	9.68 a	9.78 b	9.65 a	10.60 b	0.24	NS	*	NS
CP	26.55 a	23.03 b	25.74 a	23.45 b	0.41	NS	**	NS
EE	5.71	5.64	5.52	5.98	0.33	NS	NS	NS
CF	18.59 a	22.17 b	19.72 a	21.46 b	0.41	NS	**	NS
NDF	47.55 ab	48.90 b	46.30 a	47.60 b	0.44	NS	*	NS
ADF	27.21 ab	28.40 b	26.10 a	27.40 b	0.39	NS	*	NS
ADL	12.60 ab	13.60 b	11.70 a	12.70 b	0.33	NS	*	NS
NFE	40.25	39.96	38.30	38.45 b	0.99	NS	NS	NS
CT, g/kgDM	3.4	3.8	3.3	3.9	0.41	NS	NS	NS

[a-c] Means with different superscripts in the same row are significantly different (P<0.05).
SEM = Standard error of the mean (n=4)
***, ** = Significant at 0.05 and 0.001 probability level, respectively, NS = Non significant (P>0.05).**
[1/] V = Varieties, SC = Subsequent cutting, VS = Interaction between V and SC.
[2/] T1VKU50-S2 = KU50 and SC = 2 month; T2VKU50-S3 = KU50 and SC = 3 months; T3VRY72-S2 = RY72 and SC = 2 month; and T4VRY72-S3 = RY72 and SC = 3 months.
[3/] CT:condensed tannins

The values of NDF, ADF and ADL in the present study were similar to those reported by Wanapat *et al*. (1997) and Petlum *et al*. (2001), but were lower than those of Poungchompu *et al*. (2001) and Hong *et al*. (2003). The differences were probably due to differences in cassava varieties, age of plant, soil fertility, harvesting frequency and season and climate. Moreover, NDF and ADF values of CH were lower than those of tropical grasses and much lower than rice straw (Wanapat and Devendra,1999). Consequently, NDF and ADF values were remarkably low which indicated that the good feeding value for ruminants in terms of feed intake and digestibility.

Crude protein content in cassava hay in the present study varied between 23.03 to 26.55% and was slightly lower in subsequent cuttings of 3 months. However, similar values for CH have been previously reported by Ravindran (1993); Wanapat *et al*. (1997); Moore and Cock (1985); Hong *et al*. (2003) and Vongsamphanh and Wanapat (2004), but were higher than those of Pounchompu *et al*. (2001) and Petlum *et al*. (2001). Moreover, CP value of CH in the present study was higher than typical values for alfalfa,16.6-21.8% (Buscaglia *et al*., 1994). However, ash content in CH ranged from 9.6 to 10.6% and was dramatically higher in subsequent cuttings at 3 months. Nevertheless, the nutritive value of CH may depend on cultivar, varieties, age of plant, plant density, soil fertility, harvesting frequency, collective harvest and seasonal conditions (Gomez and Valdivieso, 1984; Wanapat *et al*., 1997). As for season, McDowell (1985) reported that in the dry season the degree of lignification increases and the protein concentration decreases in the plants. In this study, condensed tannin (CT) content in CH (*Manihot-esculenta*, Crantz) ranged from 3.3-3.9 g/kg DM. CT content of CH was found in those reported by Wanapat *et al*. (1997) and Petlum *et al*. (2001). CT in this range was reported to be beneficial to ruminants (Reed, 1995). The presence of CT was postulated as a mechanism for protecting the protein in cassava hay, which in turn would be expected to enhance its rumen by-pass properties (Wanapat, 2003).

Table 4. Ruminal pH and temperature (^{o}C) in crossbred beef steers.

h post feeding	Temperature means +SD	pH means +SD
0	38.5 + 0.7	6.95 +0.5
44	38.5 + 0.7	6.50 +0.3
8	39.5 + 0.0	6.33 +0.4
12	39.0 + 0.0	6.50 +0.1
24	38.5 + 0.7	6.75 +0.1
48	38.0 + 0.0	6.93 +0.1
72	39.5 + 0.0	6.40 +0.4
Means +	38.6 + 0.4	6.62 +0.3

Ruminal digestibility

The average ruminal pH and temperature of steers were 6.62 and 38.6^{o}C, respectively. No differences in rumen fluid pH or temperature values were noted among steers (Table 4). Ruminal pH ranged from 6.49 to 6.66, which has been reported as optimal for microbial digestion of fiber (Hoover, 1986; Firkins, 1996).

Ruminal DM and CP disappearances of feed samples (cassava hay, CH and cassava leaf, CL) are shown in Figures 2, 3, 4 and 5, respectively. Ruminal DM and CP disappearances increased with rumen incubation time for all feed samples (0 to 72 h). Before 12 h rumen incubation, rumen disappearance was low (averaging 50%) for all treatments, indicating that short incubation time has effects on DM and CP disappearance, but after a long incubation (12-72 h rumen incubation), the effects tended to disappear. Extent of disappearance of DM and CP (at 0-72 hours) were not different (P>0.05) among the treatments. The great extent of ruminal DM and CP disappearances of CH and CLcould be attributed to the good quality forage for ruminants.

The degradable fraction (a), the potential degradation (a+b) and also degradation rate constant (c) of DM and CP were similar in all treatments both of CH and CL. Similarly, the effective degradability of DM and CP at outflow rate of 0.05/h of all treatments was not different (P>0.05) among the

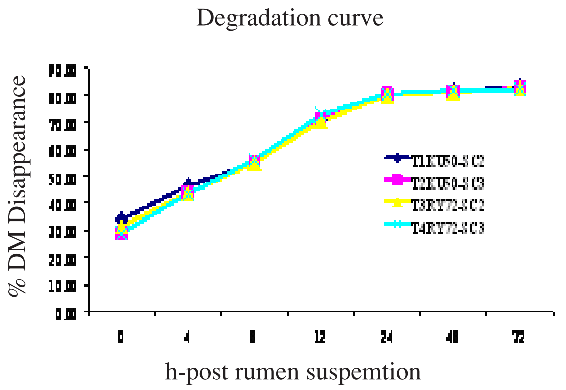

Figure 2. ***In situ*** **DM disapperance of cassava hay on breed varieties and subsequent cutting ($T1_{VKU50-S2}$= KU50 and SC = 2 month;$T2_{VKU50-S2}$ = KU50 and SC= 3 month;$T3_{VRY72-S3}$=RY72 and SC = 2 month; and $T4_{VRY72-s3}$ = RY72 and SC = 3 months) at various h-post rumen suspension.**

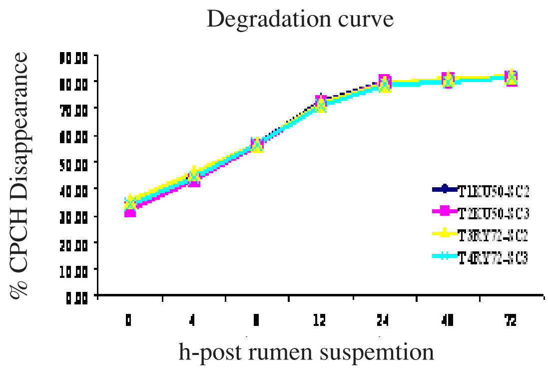

Figure 3. ***In situ*** **CP disapperance of cassava hay on breed varieties and subsequent cutting ($T1_{VKU50-S2}$=KU50 and SC=2 month;$T2_{VKU50-S2}$ =KU50 and SC=3 months ;$T3_{VRY72-S3}$= RY72 and SC=2 month; and $T4_{VRY72-S3}$=RY72 and SC=3 months) at various h-post rumen suspension**

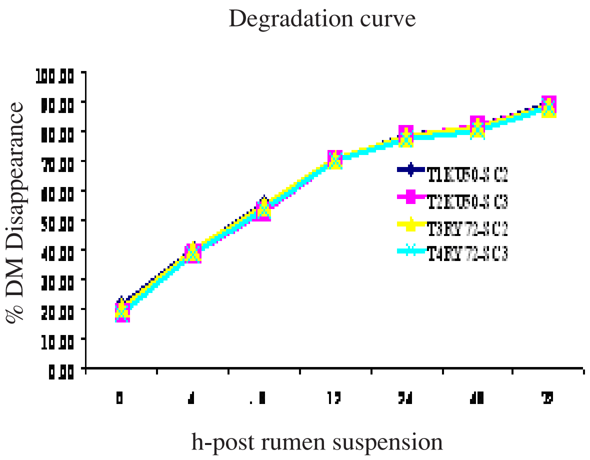

Figure 4. ***In situ*** **DM disappearances of cassava leaf on breed varieties and subsequent cutting (T1$_{VKU50-S2}$ = KU50 and SC = 2 month; T2$_{VKU50-S3}$ = KU50 and SC = 3 months; T3$_{VRY72-S2}$ = RY72 and SC = 2 month; and T4$_{VRY72-S3}$= RY72 and SC = 3 months.) at various h-post rumen suspension.**

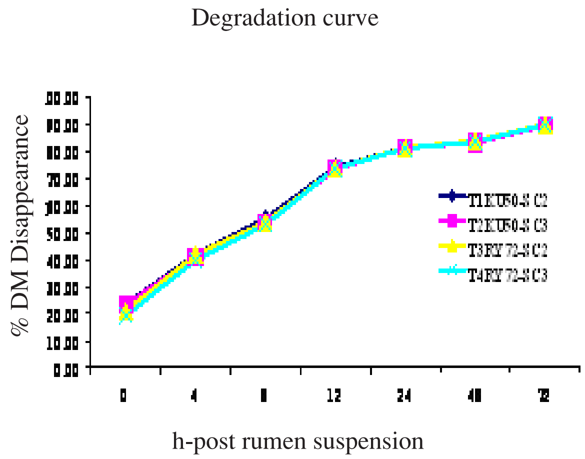

Figure 5. ***In situ*** **CP disappearances of cassava leaf onbreed varieties and subsequent cutting (T1$_{VKU50-S2}$ = KU50 and SC = 2 month; T2$_{VKU50-S3}$ = KU50 and SC = 3 months; T3$_{VRY72-S2}$ = RY72 and SC = 2 month; and T4 $_{VRY72-S3}$ = RY72 and SC = 3 months.) at various h-post rumen suspension.**

treatments (Table 5), averaging 64.7, 65.0 and 63.1 64.7%, respectively. These data are in accordance with reports by Paengkoum *et al*. (2002), who used *in sacco* technique. Similarly, the effective degradability value (0.05/h) of CH was not different from those for *Gliricidia sepium*, but higher than that for *Leucaena leucocephala* (Khamseekhiew *et al.,* 2001). Moreover, CP degradability of CH in the intestinal (mobile bag techniques) was significantly higher than for leucaena foliage (Paengkoum *et al.,* 2002). This was probably due to CH high ruminal by pass protein since it contained tannin-protein complex (Reed *et al*., 1982). In this study, CT in CH was present at 3.3-3.9 g/kg DM. This may have led to increased absorption of essential amino acid (EAA) from the small intestine and increased animal productivity without affecting VFI, thus improving the efficiency of food conversion. These data support earlier work (Terrill *et al*., 1992; Wang *et al*.,1996), showing that medium CT concentrations (30-40 g/kg DM) have no effect upon voluntary feed intake (VFI) but have reduced protein solubility and degradation in the rumen (Min *et al*., 2001), and increased the absorption EAA from the small intestine (Waghorn *et al*., 1987; Barry and McNabb, 1999). In our experiment, however, disappearance from nylon bag did not reveal effects on the total tract disappearance and the intestinal digestibility of feeds. These may differ among feed sources and the possibility of an overprotection effect will be further investigated in studies of intestinal digestibility using a mobile bag technique (De Boer *et al*., 1987).

Conclusions and recommendations

Based on this research, it was concluded that varieties and timing of subsequent cuttings had no significant effects on DM and protein yield of CH, but chemical composition was found the significantly different in subsequent cuttings. KU_{50} and SC of 3 months tended to produce higher DM and protein yield than other treatments. The ruminal disappearance characteristics of CH and CL, likewise the effective degradability of DM and CP at outflow rate of 0.05/h of all treatments, were not different (P>0.05) among the treatments. Cassava hay contained high levels of nutrient especially

Table 5. Dry matter (DM) and crude protein (CP) disappearance of cassava hay in the rumen of breed varieties and subsequent cutting (T1VKU50-S2 = KU50 and SC = 2 month; T2VKU50-S3 = KU50 and SC = 3 months;T3VRY72-S2 = RY72 and SC = 2 month; and T4VRY72-S3 = RY72 and SC = 3 months) at various incubation times in crossbred beef steers.

Item	KU50		RY72		SEM
	$T1_{VKU50-S2}$ [1/]	$T2_{VKU50-S3}$	$T3_{VRY72-S2}$	$T4_{VRY72-S3}$	
Degradability parameters					
DM disappearance of CH, %					
a	33.9	29.0	31.5	29.0	1.68
b	48.9	53.4	50.7	53.3	1.63
c	0.11	0.12	0.12	0.14	0.02
a+b	82.8	82.4	82.2	82.3	0.65
[2/] Effective degradability, %	65.2	64.3	64.6	64.8	0.41
CP disappearance of CH, %					
a	34.5	32.2	35.6	34.0	1.38
b	47.0	49.4	46.3	47.0	1.52
c	0.14	0.14	0.13	0.13	0.06
a+b	81.5	81.6	81.9	81.0	0.55
[2/] Effective degradability, %	65.4	64.6	65.4	64.6	0.92
DM disappearance of CL, %					
a	19.7	18.4	20.0	18.4	0.72
b	66.2	66.6	64.4	65.4	0.57
c	0.12	0.11	0.12	0.12	0.01
a+b	85.9	85.0	84.6	83.8	0.87
[2/] Effective degradability, %	64.2	62.8	63.3	62.2	0.81
CP disappearance of CL, %					
a	23.3	23.3	20.9	19.2	1.43
b	63.1	62.9	65.8	67.2	1.52
c	0.12	0.12	0.11	0.12	0.06
a+b	86.4	86.2	86.7	86.4	0.35
[2/] Effective degradability, %	65.36	64.44	64.85	63.93	0.62

[a-c] Means with different superscripts in the same row are significantly different (P<0.05).

SEM = Standard error of the mean (n=4)

***, ** = Significant at 0.05 and 0.001 probability level, respectively, NS = Non significant (P>0.05).**

[1/] $T1_{VKU50-S2}$ = KU50 and SC = 2 month; T2VKU50-S3 = KU50 and SC = 3 months;

$T3_{VRY72-S2}$ = RY72 and SC = 2 month; and T4VRY72-S3 = RY72 and SC = 3 months.

[2/] Effective degradability in the rumen (assuming rate of passage of $0.05/h^{-1}$).

protein content; moreover, the high value of yield of biomass and CP in all parts indicates the potential for use in ruminant feeding.

Cassava could therefore be cultivated to produce CH with high nutritive value in the southern conditions. However, in order to improve DM yield and chemical composition of CH, further research relating to planting pattern, fertilization, planting space and feeding trials should be conducted to confirm and provide practical recommendations to small-holder ruminant farmers especially those in the tropics.

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