Livestock Research for Rural Development 20 (supplement) 2008 | Guide for preparation of papers | LRRD News | Citation of this paper

The effect of molasses on the quality of Kudzu silage and evaluation of feed intake and digestibility of diets supplemented with Kudzu silage or Kudzu hay by heifers

Nguyen Van Hiep, Hans Wiktorsson* and Ngo Van Man

Faculty of Animal Science and Veterinary Medicine, Nong Lam University, Ho Chi Minh City, Vietnam
nguyenvanhiep5@yahoo.com
** Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, P.O. Box 7024, S-750 07 Uppsala, Sweden*

Abstract

Two experiments were carried out to evaluate the ensiling of Tropical Kudzu (*Pueraria phaseoloides*) and the feed intake and digestibility of Kudzu silage and Kudzu hay. In the first experiment four levels of sugarcane molasses (653 g DM kg^{-1}, 528 g WSC kg^{-1} DM) with application rates of 0, 30, 60 and 90 kg per tonne of fresh Kudzu and two storage periods (20 and 50 days) were allocated in a 4x2 factorial complete randomized design with 3 replicates. A total of 48 plastic buckets with 10 kg fresh materials in each were prepared, and 24 buckets were for determining only pH at 7 and 14 days after ensiling. In the second experiment to measure feed intake and digestibility, Kudzu vine silage with 6% of sugarcane molasses and Kudzu hay was used in the experiment. Six crossbred Red-Sindhi heifers, 8-10 months of age and 150-180 kg live weight, were randomly allocated in a repeated randomized complete block design (RCBD) two times with three treatments: Guinea grass 280 diet (Control), grass diet with a supplement of Kudzu silage (KS), and grass diet with a supplement of Kudzu hay (KH). During the feed intake measurement the grass, Kudzu silage and Kudzu hay were supplied ad libitum. For the digestibility determinations the diet was limited to 85% of mean dry matter intake measured.

Tropical Kudzu foliage can be preserved by making hay or silage. In the silage making process sugarcane molasses additive should be at least 3% of fresh Kudzu. Diet DM intake increased with the preserved Kudzu foliage, especially with the Kudzu hay supplement. The OM and CP apparent digestibility coefficients of Kudzu silage were 61.6 and 54.7%, and of Kudzu hay were 62.1 and 58.1%, respectively. The higher digestibility of Kudzu hay and Kudzu silage than grass and the higher intake with the supplemented diets should result in improved growth rate of cattle.

Key words: Cattle, Guinea grass, protein, Red-Sindhi

Introduction

Tropical Kudzu (*Pueraria phaseoloides*) is a leguminous plant that has high levels of CP (12-24 % of DM). Kudzu has been intercropped with rubber trees to improve soil fertility and with other perennial trees. In south-west Nigeria, unfertilized mixtures of Kudzu with guinea grass or elephant grass produced 13.6 tonnes/ha/year of DM and transferred approximately 40 kg/ha N to the grasses (Tropical Forages website).

In Vietnam Kudzu can be found naturally and has been introduced to interplant with rubber recently. According to the agricultural final report of the Vietnam General Rubber Corporation (GERUCO 2005) in the Southeast region of the country the total new established or replanted rubber areas was 17,251 ha, of which 6,292 ha have been inter-planted with Tropical Kudzu or Mucuna (*Mucuna pruriens*) that made up more than 36% the area. Biomass production of the cover-crops has been used as a green manure for the rubber fields. There is no demonstration of using this product as animal feed, due to its low palatability and low acceptance as green forage (farmer communication). It had been reported in the Tropical Forage website that Kudzu forage was commonly of low to moderate palatability in grazing cattle during in the wet season, but relative palatability increases substantially at flowering.

The feed intake or the palatability of legume forage is regulated by many factors: harvesting, physical and metabolic feedback, and secondary compounds. Preservation method may affect these factors, especially in reducing the secondary compounds, the anti-nutritional substances, commonly present in legume forage. Hay making is the simplest method in forage preservation and effective in reducing by evaporation toxic compounds like cyanogens (Khang and Wiktorsson 2000; Phuc et al 1996).

In the tropical humid regions, high humidity in the atmosphere and more rains in the production period limit the time of making hay, and ensiling is considered to be the most promising preservation technique. Ensiling protein rich foliage may have some constraints due to the low water soluble carbohydrates content, high buffering capacity and low dry matter content when directly harvested (McDonald et al 2002). Molasses is a good silage additive, because it is high in water soluble carbohydrates content (about 500 g/kg DM) and reduced the pH and ammonia levels in treated silages (McDonald et al 2002). Sugarcane molasses, a common feed ingredient in Vietnam, is commonly used as an additive for ensiling low WSC tropical forages and improving silage quality.

The objectives of the experiment were to determine the influence of different amounts of sugarcane molasses in making Tropical Kudzu silage and to evaluate the feed intake and digestibility of Kudzu silage and Kudzu hay by crossbred Sindhi heifers.

Materials and methods

Foliage preservation experiment

Experimental site

The experiment was conducted from August to November 2006 at the Nong Lam University Experimental Farm, Ho Chi Minh City, Vietnam.

Experiment design and treatments

Four levels of sugarcane molasses (653 g DM kg^{-1}, 528 g WSC kg^{-1} DM) with application rates of 0, 30, 60 and 90 kg per tonne of fresh Kudzu and two storage periods (20 and 50 days) were allocated in a 4x2 factorial complete randomized design with 3 replicates. A total of 48 plastic buckets with 10 kg fresh materials in each were prepared, and 24 buckets were for determining only pH at 7 and 14 days after ensiling.

Silage making

Tropical Kudzu foliage was collected in a rubber plantation in the second establishment year. Kudzu foliage 2.5 months age in the second year was cut at 20 - 30 cm above ground level, chopped by hand immediately into small pieces of 4 - 8 cm length. Sugarcane molasses was mixed with the chopped pieces at the time of filling and the materials were compacted by hand pressing in 2-layer plastic bags that were then put in plastic buckets (40cm diameter). Each bag contained around 10 kg. After filling up to the top of the bucket, the plastic bags were bound by rubber bands. The buckets were stored in shade under a roof.

Chemical analyses

Samples were collected for chemical analysis immediately before ensiling and on two later occasions, 20 and 50 days after ensiling. The physical characteristics of the silages: color, presence of fungus and smell were evaluated and the following determinations were made: pH (pH-ORION model 420 A), and DM, CP, NH_3 and ash were analyzed using procedures described by AOAC (1990). ADF was analyzed according to Van Soest et al (1991).

Statistical analysis

The data were subjected to an analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of Minitab software version 13. When the F test was significant ($P<0.05$), Tukeyǿs test for paired comparisons was used (Minitab 13).

Feed intake and digestibility study

Location and climate of the study area

The experiment was conducted from October through December 2006 at the Nong Lam University Experimental Farm, Ho Chi Minh City, Vietnam.

Experiment feed

Tropical Kudzu foliage, which is a cover crop in the rubber plantation at 2.5 months age in the second year, was cut at 20-30 cm above ground and chopped into pieces of 4-8 cm length (DM content of 19.5%). The Kudzu silage, with 6% of sugarcane molasses was made using the same method as in the ensiling study, and stored in 2-layer plastic bags of 1 m diameter. At the same time, chopped pieces of Kudzu foliage were sun dried for 3 days to reach a moisture content of less than 12%. The Kudzu hay was packed in plastic bags. All the Kudzu silage and Kudzu hay bags were stored in shade under a roof before being used in the experiment.

Guinea grass 280 (*Panicum maximum* cv. 280) was prepared in an area of 4200 m^2 and cut fresh every day at 6 weeks of age and used as the basal feed. Fresh grass was cut at 7:00h to 8:00h every day.

Experimental design and treatments

Kudzu vine silage with 6% of sugarcane molasses and Kudzu vine hay was used in the experiment. Six crossbred Red-Sindhi heifers, 8-10 months of age and 150-180 kg live weight, were randomly allocated in a 3 x 2 change-over design (Patterson and Lucas 1962) with three treatments: Guinea grass 280 diet (Control), grass diet with a supplement of Kudzu silage (KS), and grass diet with a supplement of Kudzu hay (KH). Each period included a preliminary time of 10 days for adaptation, 5 days for feed intake measurement, and 5 days for digestibility measurement. During the feed intake measurement the grass, Kudzu silage and Kudzu hay were supplied ad libitum (a surplus of 20% of the mean feed intake in the adaptation period). For the digestibility determinations the diet was limited to 85% of mean dry matter intake measured during the adaptation. During the digestibility study the daily amount of feed was constant.

The animals were confined in individual stalls under roof one month before the trial to accustom them to the experimental conditions. They were treated for internal and external parasites. During the experiment the animals were fed four times per day: at around 8.00h, 11.00h, 14.00h and 18.00h.

Kudzu was taken from the reserve bags once per day, weighed and put into a smaller plastic bag for feeding the whole day. The grass and Kudzu were fed in individual mangers. Water was freely available.

Data collection and laboratory analysis

The animals were weighed prior to and after the 5-day feed intake time in the morning, before feeding and watering. The mean weight of the heifers was used in calculating the feed intake per kg live weight. Daily feed intake was recorded as the difference between offered feeds and refused feeds the following morning. The offered and refused feeds were sampled for analysis every day at 08.00h. During the digestibility study, faeces from each animal were collected immediately after defecation throughout the day, and placed in pre-tared plastic basins until 08.00h the following morning. The 24-hour faecal output was weighed, mixed and sub-sampled, and 10% of daily output was sampled from each individual heifer and stored in a deep freezer. The samples from each animal during the collection week were de-frosted, mixed, sampled and dried in a forced oven at 60^0C for 48 hours for laboratory analysis. Samples were prepared using procedures described by Goering and Van Soest (1970). Feed, refusals and faeces samples after oven drying were ground using a laboratory hammer mill with 1 mm screen. The following determinations were made: DM, ash and CPwere analysed according tp AOAC (1990). NDF, ADF and lignin were analyzed using the methods of Van Soest et al (1991). Digestible energy content of the diets was calculated from the *in vivo* OM digestibility, according to Butterworth (1964): DE = 0.1705*OMD + 0.637.

Statistical analysis

The data were subjected to an analysis of variance (ANOVA) by using the General Linear Model (GLM) procedure of Minitab software version 13. When the F test was significant (P<0.05), Tukeyôs test for paired comparisons was used (Minitab 13).

Results

Chemical composition of silage materials

The chemical composition of silage materials is shown in Table 1. The DM and CP content of Kudzu foliage was 19.5 and 18.7%, respectively. The WSC content of Kudzu foliage was 1.1 % of DM. Molasses had a moderate level of DM of 65.3% and a WSC content of 52.8% of DM.

Table 1. Chemical composition of molasses and fresh Kudzu foliage

Item	Molasses	Kudzu foliage
DM %	65.33	19.50
% in DM		
CP	8.30	18.72
Ash	nd	10.36
NDF	nd	57.40
ADF	nd	40.20
WSC	52.78	1.11

nd: not determined

pH value of silage

The pH values of silage after different storage times and molasses rate are shown in Table 2 and Figure 1.

Table 2. Effect of molasses on the pH of Kudzu silage

Storage, days	Molasses rate				Mean	SEM	P
	0%	3%	6%	9%			
7	5.29	4.39	4.18	4.00	4.46		
14	5.11	4.36	4.32	4.09	4.47	0.079	0.908
20	5.16	4.55	4.21	4.23	4.54		
50	5.13	4.53	4.18	4.28	4.53		
Mean	5.17^{a}	4.46^{b}	4.22^{bc}	4.15^{c}			
SEM		0.079					
P		0.000					

^{abc} *means within rows with differing superscript letters are significantly different*

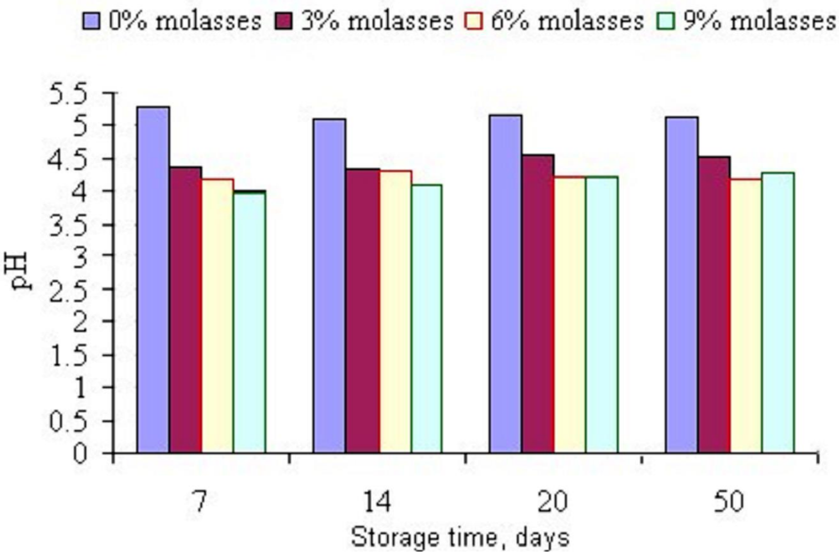

Figure 1. Effect of molasses and storage time on pH of silage

At 7 days after ensiling the pH values of all treatments went down to 5.29, 4.39, 4.18 and 4.00 in treatment 0% , 3%, 6% and 9% molasses additive, respectively. At 14, 20 and 50 days after ensiling the pH values of silage in each treatment had only slight changes (3.5 to 7%). The mean silage pH value was highest in the 0% molasses treatment (5.17) and decreased significantly with the gradual increasing of molasses additive. Time of storage had no significant effect on the silage pH value, although there was a trend of a slight increase in pH value with increased storage time.

Physical quality of silage

Physical quality observations of the silage at 20 and 50 days are presented in Table 3.

Table 3. Apparent quality classification of Kudzu silage at different rate of molasses and storage time

Storage time	Molasses rate	Colour	Molds	Acceptable
20 days	0%	Yellowish brown	T-1	Yes-with
	3%	Brownish yellow	Absent	Yes
	6%	Brownish yellow	Absent	Yes
	9%	Brownish yellow	Absent	Yes
50 days	0%	Yellowish brown	T-2	Yes-with
	3%	Brownish yellow	T-1	Yes-with
	6%	Brownish yellow	T-1	Yes-with
	9%	Brownish yellow	T-1	Yes-with

T-number: only on top surface with ńnumberôcm in thickness; Yes-with: acceptable with left over

The silage color was slightly changed from a yellowish brown color on the treatment with a 0% molasses to brownish yellow in the treatments with molasses additive. No mold was seen in any silage treatment at 20 days after ensiling, except that the treatment without molasses additive had a thin layer of about 1cm on the top of the silage product. In the 50-day observation mold was seen in the top of silage bag with a thin layer of 2cm (without molasses treatment) and 1cm (with molasses treatments).

Chemical composition of Kudzu silage

The chemical composition of Kudzu silage is presented in Table 4. The mean silage DM contents were significantly increased with increased molasses rate in the Kudzu silage ($P<0.001$). The mean DM content at 20 and 50 days storage time was 23.3 and 22.8 %, respectively. There was a slight decrease of DM with a long storage time but no significant difference was found. The mean silage DM content of all treatments was higher than DM content of fresh Kudzu (18.5 %). The mean ash contents of the Kudzu silage were around 9.92 to 10.3 % of DM, and there was no significant difference among treatments of both molasses level and storage time.

Table 4. Effect of molasses and storage time on quality of Kudzu silage

Treatment	%	% in DM				%
	DM	Ash	CP	NH_3	ADF	NH_3-N/× N, %
Molasses rate						
0 %	20.25^{a}	9.92	20.99^{a}	1.082^{a}	42.16	26.35^{a}
3 %	22.57^{bc}	10.30	20.21^{ab}	0.887^{b}	40.97	22.54^{b}
6 %	23.38^{c}	10.25	19.56^{ab}	0.742^{c}	40.85	19.53^{c}
9 %	25.96^{d}	10.33	19.22^{b}	0.687^{c}	40.88	18.39^{c}
SEM	0.255	0.151	0.406	0.025	0.419	0.674
P	0.000	0.228	0.035	0.000	0.120	0.000
Storage time						
20 days	23.26	10.25	19.09	0.753	41.19	20.26
50 days	22.82	10.15	20.90	0.946	41.32	23.15
SEM	0.180	0.106	0.287	0.018	0.297	0.476
P	0.107	0.544	0.000	0.000	0.625	0.001

abc means within columns with differing superscript letters are significantly different

The mean silage CP content varied from 19.2 to 22.9 % in DM and gradually decreased with increase of molasses additive. However, a significant difference was found only between the treatment 0% molasses and 9% molasses. Storage time had a significant effect in increasing the mean CP content of Kudzu silage (P<0.001). Higher levels of molasses additive resulted in significantly lower mean NH_3 content of silage (P<0.001), except for the difference between the 6 and 9 % molasses treatments. The mean NH_3 content of Kudzu silage at 20 and 50 day storage times was 0.75 and 0.95 % of DM and longer storage time increased the NH_3 content of Kudzu silage significantly (P<0.001). A similar result for the NH_3-N/total nitrogen ratio was obtained.

Chemical composition of diet ingredients used in the feed intake and digestibility experiment

The chemical composition of the diet ingredients in the feed intake and digestibility experiment are presented in Table 5.

Table 5. Chemical composition of the dietary ingredients

Item	Ingredients		
	Guinea grass	Kudzu silage	Kudzu hay
DM %	23.50	20.15	92.12
% in DM			
OM	90.45	92.01	92.30
CP	8.55	20.09	18.23
Ash	9.55	8.14	7.70
NDF	78.00	57.10	57.40
ADF	40.83	38.32	39.15
Lignin	9.65	8.25	8.18
pH	nd	4.24	nd

nd: not determined

Kudzu silage was prepared in big bags for feeding the experimental animals, with a level of 6% molasses. The silage pH and chemical composition was the same as in the ensiling trial. The experimental Kudzu hayȻs CP and ADF content was 18.2% and 39.2% in DM, respectively, which was a little lower in CP and higher in ADF compared with the Kudzu silage used in the same trial. The Guinea grass 280 DM was 23.5% and the CP, ADF and lignin content was 8.6, 40.8 and 9.7% in DM, respectively.

Daily feed intake

The results for daily feed intake are presented in Table 6.

Table 6. Daily intake of feed DM and CP

Feed Intake	Treatment			SEM	P
	Guinea grass	KS supplement	KH supplement		
Kg / animal					
Grass	3.54	3.15	2.94	0.339	0.491
Kudzu	0.00^a	0.51^b	1.16^c	0.109	0.001
Total	3.54	3.66	4.10	0.302	0.431
Crude protein	0.31^a	0.38^a	0.50^b	0.025	0.005
NDF	2.74	2.73	2.96	0.036	0.215
Kg / 100 kg live weight					

Grass	2.05^{a}	1.75^{ab}	1.63^{b}	0.083	0.030
Kudzu	0.00^{a}	0.33^{b}	0.65^{c}	0.083	0.004
Total	2.05^{a}	2.08^{a}	2.28^{b}	0.047	0.021
Live weight (kg)	171.5	175.8	179.2	12.953	0.915

abc means within rows with differing superscript letters are significantly different

The DM grass intake per animal was highest in the sole grass treatment, followed by the KS and KH treatments. The DM Kudzu intake was 0.51 and 1.16 kg per animal with Kudzu silage and Kudzu hay, respectively. There was significantly higher Kudzu hay intake compared to Kudzu silage intake (P<0.001). The total DM intake per animal was increased by 3.5% and 16 % with KS treatment and KH treatment compared to the Guinea grass treatment, respectively, but no significant difference between the treatments was found. The CP intake increased with the supplement treatments, but a significant difference was found only between the KH treatment and the other two treatments (63.1% increase with grass treatment and 31.5% increase with KS treatment).

Digestibility of the experimental diet and the dietary ingredients

The results for apparent digestibility of the diet are presented in Table 7.

Table 7. Apparent digestibility of treatment diets (%)

Apparent digestibility	Treatment			SEM	P
	Guinea grass	KS supplement	KH supplement		
DM	57.22	58.75	59.72	1.601	0.570
OM	59.85	61.57	62.14	1.569	0.588
CP	51.06	54.71	58.09	3.182	0.343
Ash	32.48	31.69	35.77	2.868	0.660
ADF	55.84	58.34	58.02	1.891	0.611

The DM, OM, CP and ADF digestibility of Guinea grass 280 cut at 6 weeks of age was 57.2, 59.9, 51.1 and 55.8, respectively. The DM and OM digestibility of diets was slightly increased when Kudzu silage or Kudzu hay was supplemented in the grass diet (compared to pure grass diet). The increases were 1.5 and 2.5 percent DM digestibility, 1.7 and 2.3 percent OM digestibility in the Kudzu silage and Kudzu hay diet, respectively, compared to the grass diet. CP digestibility increased with the supplement and the highest was in the KH diet. The increase of CP digestibility was 3.65 and 7.03 % units in the comparison of the KS and KH diet with the grass diet. The ADF digestibility of Kudzu hay and Kudzu silage diet was similar, and both were around 3 percent units higher than in the grass diet. However, none of these differences was statistically significant.

The apparent digestibility of Kudzu silage and Kudzu hay was calculated by the difference in digestibility of the diets in the supplement trial, and this showed a higher digestibility compared with guinea grass (Table 8).

Table 8. Apparent digestibility of treatment ingredients (%) assuming constant digestibility of Guinea grass as determined in the study

Apparent digestibility	Guinea grass	Kuzdu		SEM	P
		Silage	hay		
DM	57.22^{a}	63.88^{ab}	66.98^{b}	1.237	0.012
OM	59.85^{a}	63.38^{ab}	68.27^{b}	1.582	0.048
CP	51.06	72.28	66.44	3.910	0.065
Ash	32.48	66.56	49.91	5.856	0.074

ADF	55.84[a]	76.09[b]	65.89[ab]	2.481	0.026

abc means within rows with differing superscript letters are significantly different

The increases in DM, OM and ADF digestibility were significant between the preserved Kudzu foliage and grass, but not clear between Kudzu silage and Kudzu hay. The DE per kg DM of the grass, Kudzu silage and Kudzu hay diets were 10.80, 11.13 and 11.23 MJ, respectively (Table 9).

Table 9. Digestible energy and digestible crude protein of diet and diet ingredients

Component	AR[#]	Treatment		
		Guinea Grass	KS supplement	KH supplement
Diet				
DE*, MJ/ kg DM		10.84	11.13	11.23
Daily DE intake, MJ/ animal	40	38.36	40.76	46.12
Daily DCP intake, g/ animal	202	156.2	208.4	289.9
Dietary ingredient				
DE*, MJ/kg DM		10.84	11.44	12.28
DCP, g/kg DM		44.01	132.5	132.5

**Digestible energy calculation based on OM digestibility: Butterworth (1964)*

#AR (animal requirement) requirement for heifer 150-200 kg live weight and 0.6 kg gain per day (NRC 2000)

The daily DE and DCP intakes per animal were higher in the diet supplemented with Kudzu silage and Kudzu hay compared with the sole grass diet, with the highest being in the Kudzu hay diet.

The DE and DCP values of Kudzu silage and Kudzu hay, calculated according to Butterworth (1964), were higher in the preserved Kudzu foliage, Kudzu silage and Kudzu hay compared with Guinea grass. These increases were high in DCP compared to grass but the difference between Kudzu silage and Kudzu hay (Table 9) was not so high.

Discussion

In the first trial 20 days after ensiling Kudzu silages of all molasses additive treatments were acceptable in the evaluation of color, smell, mold appearance and pH (Table 6). The pH value is often used as the criterion for assessing silage quality and all these silages had sufficiently low pH values (around 4.5) that would be considered good quality silage (Lattemae 1997). Molasses additive had a clear effect on reducing silage pH values, being the main factor that contributed to the successful ensiling of the Kudzu foliage. Without molasses additive, the silage in the control treatment was not acceptable; with a pH value higher than 5, and molds appeared at the first observation 20 days after ensiling. The WSC content, the main substrate for microbial growth in Kudzu foliage, was too low (1.1% of DM) to support a good ensiling. In summary the data from 33 experiments on the effect of silage additives and wilting on silage making, reviewed by Haigh and Parker (1985), suggested that a critical WSC concentration in herbage for successful preservation as silage without additives is 30 g kg^{-1} DM.

At 50 days after ensiling the quality of silages did not change, except for the appearance of the thin layer of molds on the top of silage bags (Table 3). The results of the visual evaluation clearly showed the increasing problems with molds and spoiled silages with the longer storage period. Man and Wiktorsson (2001), in an ensiling study of Cassava and *Gliricidia* tops, reported the same problem and found an increasing problem with molds with increasing amount of molasses, whereas in our study the opposite result was observed.

Increasing of molasses rate increased silage DM content, because the DM content of molasses is higher than that of Kudzu foliage. The same result was found by Lattemae et al (1996). There is another role of molasses additive in contributing to successful ensiling and that is when silage material has high water content and low WSC content. This is in agreement with the suggestion for more WSC in silage material for good fermentation (McDonald et al 2002).

In this study the CP content decreased in the molasses additive treatments. This is due to the high percentage of molasses in those treatments. Protein losses in the ensiling procedure might depend on the run off of proteolytic end products with the effluent (Man and Wiktorsson 2001). Extensive proteolysis occurs during the first few days of ensiling and if the pH can be reduced rapidly to 4.3 the proteolytic activity will be decreased (MacPherson 1952). In the present study the DM content of herbage materials was sufficiently high to avoid seeping and additive silage pH went down quickly to prevent the loss of silage protein.

Silage NH_3 content is another indication of silage quality. McDonald et al (2002) reported that well-preserved silage is considered to be good with less than 100 g NH_3-N/kg total nitrogen. In this study, NH_3 content and NH_3-N/total nitrogen ratio were good for all the molasses additive treatments. This can be explained by the fact that increasing molasses additive reduced pH in silage product rapidly, resulting in decreasing NH_3 production. NH_3 content and NH_3-N/total nitrogen ratio increased with longer storage time, as occurred in the treatment without molasses because of continued deamination. This result is in accordance with the report by Malavanh et al (2006) on taro silage.

In the second trial on the feed intake and digestibility, the CP content of the diets was found to be the most important factor affect DM intake. Intake often is depressed when the CP content of diets is below 7 to 8 % in DM (Blaxter and Wilson 1962; Milford and Minson 1966). The voluntary DM intake of guinea grass 280, which was the sole diet, was lower compared to data reported by Man and Wiktorsson (2001)(2.1 vs 2.4 kg/100kg LW). This may be a result of different breeds of the experimental animals. Crossbred Red-Sindhi heifers were used in the present study, while in Man�s study crossbred Holstein heifers were used. Merkel et al (1999) noted that the effect of protein supplementation to low quality roughage diets in the tropics increased feed intake. In the present study, the Kudzu hay supplement diet had higher intake than the sole grass diet, but supplementation of Kudzu silage did not increase feed intake. Low pH in silage in this study (pH=4.2) may have had a detrimental effect on palatability. McDonald et al (2002) stated that low pH reduces intake and low DM content of diets also affect DM intake.

Increased DMI in the legume supplement treatments reflected the CP intake of these treatments compared with the grass only treatment, as shown in Table 6. Kudzu hay had lower CP content than Kudzu silage, but DM intake of Kudzu hay was double that of Kudzu silage, while DM intake of grass was nearly the same in the two supplement treatments. This can be explained by the fact that CP intake of the Kudzu hay diet was highest.

The apparent digestibility of nutrients of guinea grass 280 was lower than data reported by Man and Wiktorsson (2001). The low CP content of forage may be the limiting factor related to forage digestibility. The CP in the sole grass diet was the main source of N for many species of rumen microorganisms and a low level of N intake may limit microbial growth, resulting in low fermentative digestion of grass (Man and Wiktorsson 2001). The high lignin level in grass may also make strong chemical bonds linking lignin with many polysaccharides and cell wall proteins, which renders these compounds unavailable during digestion (McDonald et al 2002). The results clearly show low CP and ADF digestibility of grass in this study. Supplementing Kudzu hay and Kudzu silage in the mixed diets tended to increase the diet digestibility. Supplementing protein-rich forage to poor quality roughage based diets increases ruminal and by-pass protein. This result is higher microbial protein synthesis, and feed intake (Premaratne et al 1998). DôMello and Devendra (1995) showed that legume leaves usually contain higher concentrations of protein and non structural carbohydrates than tropical grasses, and this may make legumes more digestible.

Kudzu foliage had still a high leaf proportion at this stage of maturity (53%), reflected in a high digestibility. A high ratio of Kudzu in the supplement diets made them higher in digestibility compared to the grass diet (Table 7). In a digestibility trial with cassava silage supplement Man and Wiktorsson (2001) reported the opposite result, with low digestibility in the supplement diets. These results were explained by the fact that the high tannin content in cassava silage may bind fiber and protein in strong chemical bonds, which make these compounds indigestible. In the present study this would not have happened, because the tannin content of Tropical Kudzu was low (<1%) according to Lowry et al (1992).

The apparent digestibility of Kudzu silage and Kudzu hay was calculated by the difference in digestibility of the diets in the supplement trial, and this showed higher in DM, OM and CP digestibility compared with guinea grass (Table 8). In the present study higher DM digestibility in Kudzu hay than Kudzu silage was found (3%). A similar result was reported by Clancy et al (1977), that making alfalfa hay by drying can improve the digestibility by 7% compared with silage making. Drying reduced the free tannin (Ahn et al 1997) and thus the binding of protein and fiber decreased (Reed et al 1990; Kumar and DôMello 1995).

Digestibility of Kudzu hay and Kudzu silage diets was high, resulting in high DE per kg feed in these diets. In addition, high feed intake increased daily DE intake, particularly on the Kudzu supplement diet. The high feed intake combined with high DCP resulted in increased daily DCP intake for the Kudzu supplement diets. As a result of the small body size, and thus requirements of the animals in the present study (Table 9), Kudzu supplement diets would have met the requirements for high growth in these cattle.

Higher OM and CP digestibility of the supplement materials increased the DE and DCP values of Kudzu silage and Kudzu hay, using the calculations of Butterworth (1964). DCP values were high compared to grass, but the differences between Kudzu silage and Kudzu hay were small.

Conclusions

- Tropical Kudzu foliage can be preserved by making hay or silage. In the silage making process sugarcane molasses additive should be at least 3% of fresh Kudzu.

- Diet DM intake increased with the preserved Kudzu foliage, especially with the Kudzu hay supplement.

- Digestibility coefficients of Kudzu silage and Kudzu hay were higher than those of grass.

Acknowledgements

Financial support from the Mekarn Project is gratefully acknowledged and the authors also thank Ms Tran Thi Phuong Dung of Nong Lam University for help with the analyses, and Mr. Dinh Cong Tien, Mr. Nguyen Ngoc Tuan, Mr. Ho Van Thinh for help with the field work.

References

Ahn J H, Elliott R and Norton B W 1997 Oven drying improve the nutritional value of *Calliandra calothyrus* and *Gliricidia sepium* as supplements for sheep given low quality straw. Journal of Science Food Agriculture 75:503-510

AOAC 1990 Official methods of analysis of the Association of Official Analytical Chemists (15th Edition). Washington, DC.

Blaxter K L and Wilson R S 1962 The voluntary intake of roughages by steers. Animal Production 4: 351

Butterworth M H 1964 The digestible energy content of some tropical forage, Journal of Agricultural Sciences (Cambridge) 63:319-321

Clancy M, Wangsness P J and Baumgardt B R 1977 Effect of conservation method on digestibility, nitrogen balance and intake of alfalfa. Journal Dairy Science 60 (4):572-579 http://jds.fass.org/cgi/reprint/60/4/572

D'Mello J P F and Devendra C 1995 Tropical legumes in animal nutrition. CABI Publishing. UK.

GERUCO 2005 Annual agricultural final report of Vietnam General Rubber Corporation (translate). http://www.vngeruco.com/index.php.

Goering J K and Van Soest P J 1970 Forage Fiber Analysis. Agricultural Hand Book No. 379. Agricultural Research Service, United States Department of Agriculture, Washington DC.

Haigh P M and Parker J V G 1985 Effect of silage additives and wilting on silage fermentation, digestibility and intake, and on live weight change of young cattle. Grass and Forage Science 40:429-436

Khang D N and Wiktorsson H 2000 Effects of cassava leaf meal on the rumen environment of local yellow cattle fed urea treated paddy straw. Asian-Australasian Journal of Animal Sciences 13 (8):1102-1108

Kumar R and D'Mello J PF 1995 Antinutritional factors in forage legumes. In: D'Mello J P F and Devendra C (Editors), Tropical legumes in animal nutrition. CABI Publishing, UK.

Lattemae P 1997 Ensiling and evaluation of forage crops. Dissertation, Swedish University of Agricultural Sciences. Report 32. Uppsala.

Lattemae P, Olsson C and Lingvall P 1996 The combined effect of molasses and formic acid on quality of red clover silage. Swedish Journal of Agricultural Research 26:31-41

Lowry B J, Petheram J R and Tangendjaja B 1992 Plants fed to village ruminants in Indonesia. ACIAR Technical Reports No. 22. Canberra.

MacPherson H T 1952 Changes in nitrogen distribution in crop conservation**.** Journal of Science of Food and Agriculture 3:362-267

Malavanh C, Preston T R and Ogle R B 2006 Ensiling leaves of Taro (*Colocasia esculenta)* with sugarcane molasses. Workshop on forages for pigs and rabbits. Phnom Penh. Cambodia. http://www.mekarn.org/proprf/mala.htm

Man N V and Wiktorsson H 2001 Cassava tops ensiled with or without molasses as additive: effects on quality, feed intake and digestibility by heifers. Asian-Australasian Journal of Animal Sciences 14 (5):624-630

McDonald P, Edwards R A, Greenhalgh J F D and Morgan C A 2002 Animal Nutrition (6th Edition). Longman Scientific a Technical. Harlow, England.

Merkel R C, Pond K R, Burns J C Fisher D S 1999 Intake, digestibility and nitrogen utilization of three tropical tree legumes. II As protein supplement. Animal feed science and technology 82:107-120

Milford R and Minson D J 1966 Intake of tropical pasture species. Proceeding of the IX international grassland congress. Sao Paulo, Brazil.

NRC 2000 Nutrient Requirements of Beef Cattle: Seventh Revised Edition: Update 2000 National Research Council. USA http://www.aces.edu/department/aawm/anr-60.pdf

Patterson H D and Lucas H L 1962 Change-over Designs. North Cafolina Agricultural Experiment Station. USA. Techical Bulletin No. 147

Phuc B H N, Ogle R B, Lindberg J E and Preston T R 1996 The nutritive value of sun-dried and ensiled cassava leaves for growing pigs. National Seminar-Workshop Sustainable livestock production on local feed resources. Ho Chi Minh, Vietnam.

Premaratne S, Van Bruchem J, Chen X B, Perera H GD and Oosting S J 1998 Effect of type and level of supplementation on voluntary intake, digestion and microbial protein synthesis and growth in sheep fed basal diet of rice straw and cassava. Asian-Australasian Journal of Animal Science 11: 692-696

Reed J D, Soller H and Woodward A 1990 Fodder tree and straw diets for sheep: intake, growth, digestibility and the effects of phenolics on nitrogen utilization. Animal feed science and technology 30:39-50

Van Soest P J, Robertson J B and Lewis B A 1991 Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. Journal of Dairy Science 74:3583-3597 http://jds.fass.org/cgi/reprint/74/10/3583.pdf

Go to top