Trop Anim Health Prod
DOI 10.1007/s11250-016-1107-5

SHORT COMMUNICATIONS

The use of cassava leaf silage as a substitute for concentrate feed in sheep

A. Sudarman[1] · M. Hayashida[2] · I. R. Puspitaning[1] · A. Jayanegara[1] · H. Shiwachi[3]

Received: 15 September 2015 / Accepted: 30 June 2016

Abstract We aimed to evaluate nutrient intake, performance and rumen fermentation of sheep fed cassava leaf silage (CLS). Sixteen growing Java thin-tailed male sheep (body weight (BW) 20.4 ± 1.9 kg) were fed one of the following dietary treatments: T0 (100 % forage); T1 (100 % chopped forage); T2 (80 % chopped forage + 20 % concentrate); and T3 (80 % chopped forage + 20 % CLS). Nutrient intake, production performance and rumen fermentation characteristics were measured. There was no significant effect on the consumption of dry matter, whereas there was a significant effect ($P < 0.05$) on the consumption of crude protein, fat, crude fibre and total digestible nutrients. Concentrate or CLS at a 20 % level could increase BW and feed efficiency. No significant difference was observed in total bacteria; however, concentrate could increase total protozoa ($P < 0.05$). Total volatile fatty acids were higher in T2 than in T3, but ammonia concentration was higher in T3 than in T2. In conclusion, feeding 20 % cassava leaf silage greatly improved sheep performance, approaching that achieved by feeding concentrate.

Keywords Cassava leaf silage · Concentrate · Rumen fermentation characteristics · Sheep

A. Sudarman and M. Hayashida contributed equally to this work.

✉ M. Hayashida
m4hayash@nodai.ac.jp

A. Sudarman
a_sudarman@yahoo.com

H. Shiwachi
h1shiwac@nodai.ac.jp

1 Department of Nutrition and Feed Technology, Faculty of Animal Science, Bogor Agricultural University, Bogor 16680, Indonesia

2 Department of Bioproduction Technology, Junior College of Tokyo University of Agriculture, Tokyo 156-8502, Japan

3 Department of International Agricultural Development, Faculty of International Agriculture and Food Studies, Tokyo University of Agriculture, Tokyo 156-8502, Japan

Introduction

Sheep production in Indonesia has largely been supported through smallholder farmers. The main feed resources used are field grasses and legumes; however, these are limited during the dry season, resulting in inadequate nutrient supply that further decreases production. Although concentrate feeds could improve the nutrient content, farmers often refuse to use it because of its high cost. To overcome this problem, the use of high quality but abundant forages has been attempted.

Cassava (*Manihot esculenta* Crantz) is one of the main agricultural crops in Indonesia. The roots of cultivated cassava are harvested to produce food, and starch may be extracted for industrial purpose. Cassava leaves are rich in crude protein (CP) content (177–381 g/kg dry matter (DM)) (Latif and Mueller 2015). The production of cassava has amounted to 10–40 million tonnes/year; however, only 800 tonnes/year is used as food for human consumption. Thus, the leaves are highly suited for utilisation as animal feeds.

The high content of hydrocyanic acid (HCN) and tannin limit the use of cassava leaves in animal feed (Reed et al. 1982; Soto-Blanco and Gorniak 2010). At a high concentration, HCN is toxic and can be deadly to ruminants. Ensiling is evidently an effective way of decreasing the cyanide concentration in cassava leaves (Nguyen et al. 2012).

Published online: 09 July 2016

The present study was conducted to evaluate nutrient intake, performance and rumen fermentation characteristics of sheep fed cassava leaf silage.

Materials and methods

The study was conducted at a smallholder farm located at Petir village, Bogor, Indonesia, for 12 weeks with a 2-week adaptation period. Fresh cassava leaves (top stalks and top trunks) were chopped (2–3 cm) and wilted for 6 h at ambient temperature. Molasses (5 %) was then added and thoroughly mixed before storage at ambient temperature in 30-kg sealed airtight plastic bags for at least 3 weeks before being fed to the sheep. A homogenous sample was collected for pH and chemical analysis. The average pH of cassava leaf silage in the present study was 4.

Sixteen growing Java thin-tailed male sheep with an average body weight (BW) of 20.4 ± 1.87 kg were housed individually in 16 pens provided with facilities for feed and drinking water. Before the experiment, animals were weighed, shorn (to eliminate effect of different fleece length affecting heat stress responses of animals) and dewormed using Kalbazen-SG. The animal weighing was repeated at 7-day intervals, always in the morning before feeding.

Animals were divided into four groups according to body weight, each of which received one of the dietary treatments. The experimental diets were formulated on the basis of concentrate, cassava leaf silage (CLS) and forage (local grass, corn leaves and sweet potato vines with a similar ratio per day) as follows:

T0: 100 % forage
T1: 100 % chopped forage
T2: 100 % chopped forage + 20 % concentrate
T3: 100 % chopped forage + 20 % CLS

The concentrate used consisted of coconut meal, tapioca by-product, groundnut meal, pollard, $CaCO_3$, premix and salt. The nutrient content of feed was determined using proximate analysis (AOAC 2000; Table 1). The daily feeding rate was 3.0 kg/100 kg body weight given at 7:00, 12:00 and 17:00 h, whereas water was provided ad libitum during the maintenance period. Daily feed refusals were collected and weighed in the morning before feeding.

Approximately 15–20 ml of rumen liquor was collected from each animal using a stomach tube during the last week of maintenance at 4 h after feeding. Samples were filtered and analysed for protozoa (Ogimoto and Imai 1981), bacteria, ammonia concentration (Conway 1962) and total volatile fatty acids (VFAs) using the steam distillation method (General Laboratory Procedures 1966).

The experimental design used was a randomised complete block design by using four treatments with four replicates for each treatment. Data were subjected to analysis of variance (ANOVA), and any significant difference ($P < 0.05$) among means was further tested by Duncan's multiple range test using SPSS for Windows version 16.0 (SPSS Inc. 2007, Chicago, USA).

Results

Ensiling decreased both HCN and tannin contents of cassava leaves, from 333 to 71.0 mg/kg and from 14.9 to 8.53 % DM, respectively. There were no significant differences in DM intake among the treatments (Table 2). A significantly higher CP intake ($P < 0.01$) was observed in the animals fed CLS (T3). The body weight gains (BWG) and feed efficiencies for T0 and T1 were significantly lower ($P < 0.05$ for both) than those for T2 and T3. The highest population of protozoa was found in sheep fed T2 (Table 3). There were no significant differences in bacterial population among groups. Sheep fed T1 had significantly higher ($P < 0.05$) total VFA production than those fed T0. T2 feeds produced the highest total VFA. The

Table 1 Nutrient content of the experimental diets based on the dry matter (DM)

	DM g/kg	Ash	CP	CF	CFat	NFE	TDN
Forage[a]	182	112	177	303	20.0	388	567
Concentrate	885	115	124	188	43.5	531	692
Cassava leaf silage	270	42	248	211	32.7	465	771
T0	182	112	177	303	20.0	388	567
T1	182	112	177	303	20.0	388	567
T2	323	113	167	280	24.7	417	592
T3	200	98	191	284	22.5	404	608

DM dry matter, *CP* crude protein, *CF* crude fibre, *CFat* crude fat, *NFE* nitrogen-free extract, *TDN* total digestible nutrients

[a] Forage ration: corn leaves: local grass: sweet potato leaves = 4.20:19.1:76.7

Table 2 Average of nutrient intake, body weight gain (BWG) and feed efficiency of sheep fed experimental diets

	Treatments			
	T0	T1	T2	T3
Nutrient intake (g/kg BW$^{0.75}$/day)				
DM	75.4 ± 2.18	73.4 ± 2.52	74.3 ± 4.83	75.5 ± 1.79
CP	13.4 ± 0.39b	13.0 ± 0.45b	12.4 ± 0.80c	14.1 ± 0.34a
CF	22.8 ± 0.66a	22.2 ± 0.76a	20.8 ± 1.35b	21.0 ± 0.51b
Cfat	1.51 ± 0.04c	1.47 ± 0.05c	1.84 ± 0.12a	1.66 ± 0.04b
NFE	29.3 ± 0.85	28.5 ± 0.98	31.0 ± 2.01	29.8 ± 0.72
TDN	42.8 ± 1.24ab	41.6 ± 1.43b	44.0 ± 2.86a	44.9 ± 1.09a
BWG (g/h/day)	30.2 ± 11.2b	31.9 ± 16.1b	63.3 ± 25.7a	53.6 ± 17.4ab
(%)	9.57 ± 2.89b	10.6 ± 5.53b	20.3 ± 7.36a	17.3 ± 4.93a
Efficiency (%)	3.68 ± 1.06b	4.06 ± 1.99b	7.51 ± 2.44a	6.53 ± 1.73a

DM dry matter, *CP* crude protein, *CF* crude fibre, *Cfat* crude fat, *NFE* nitrogen-free extract, *TDN* total digestible nutrients, *BWG* body weight gain

highest ammonia concentration was observed in the animals fed T3. Sheep fed T1 had a significantly higher ($P < 0.05$) ammonia concentration than those fed T0.

Discussion

The insignificant differences between DM intakes indicated the same palatability between treatments. The addition of CLS to the diet increased the intake of CP and total digestible nutrients (TDN), because of a higher concentration of CP and TDN within CLS. DM intake (3.18–3.38 % BW) indicated that feeding was sufficient to meet the maintenance requirement of sheep. The chopped treatment tended to increase BWG and feed efficiency because the particle size of T1 was smaller than that of T0. The highest BWG and feed efficiency occurred with the addition of concentrate, showing that concentrate maintained the stabilisation of BW during fluctuated foraging. Using CLS in the diet (T3) could produce the same feed efficiency and BWG as using concentrate in the diet (T2).

T2 had a higher starch content as compared to the other treatments. Most of the protozoa were found in the digested starch in the rumen; therefore, the protozoa may develop rapidly in the rumen of sheep fed concentrate. Ramos et al. (2009) reported that an increase of concentrate ratio in the diet could increase the population of rumen protozoa in sheep. No significant difference in the population of protozoa was found between T0, T1 and T3 resulting from a diet consisting of 100 % forage. The protozoa population observed in the present research (5.84–6.15 log cells/ml) was similar to that reported by Rodriguez et al. (2015) of 5.83 log cells/ml in the rumen of sheep fed 100 % elephant grass.

The total bacteria observed in the present study (8.43–8.84 log cfu/ml) remained in the normal range for rumen of a ruminant. In the sheep fed a high feed forage, the total rumen bacteria was 8 log cfu/ml (Ramos et al. 2009).

Sheep fed T1 had significantly higher ($P < 0.05$) total VFA production than those fed T0, which may be caused by the feed particle size. A small feed particle size was easier to digest than large particle size at 4 h after feeding. Bhandari et al. (2007) reported that reduction of particle size in alfalfa

Table 3 Rumen fermentation characteristics of experimental sheep

	Treatments			
	T0	T1	T2	T3
Rumen fermentation				
Total VFA (mM)	79.9 ± 9.87c	98.0 ± 5.95ab	111 ± 15.5a	87.6 ± 13.3bc
NH_3 (mM)	8.97 ± 3.09b	10.0 ± 4.86ab	6.24 ± 1.97b	14.6 ± 1.25a
Total bacteria (log cfu/ml)	8.48 ± 0.18	8.75 ± 0.58	8.43 ± 0.31	8.84 ± 0.42
Protozoa population (log cell/ml)	5.84 ± 0.11b	5.94 ± 0.02b	6.15 ± 0.15a	5.87 ± 0.05b

VFA volatile fatty acids

could increase the total production of VFA at 4–5 h after feeding. T2, which produced the highest total VFA because of its starch content, was faster to digest than forage.

The highest ammonia concentration in the animals fed the CLS diet most likely resulted from higher nitrogen levels in the rumen resulting from the increased consumption of CP. Sheep fed T1 had a significantly higher ($P < 0.05$) ammonia concentration than those fed T0; this may be because of the particle size of feed. The larger the particle size of feed, the more difficult it would be to digest. According to Zhao et al. (2009), increasing particle size of feed could decrease ammonia concentration in the rumen.

Acknowledgments The authors thank 'International Cooperative Research Project (TUA-IPB-MSU)' of Tokyo University of Agriculture for the financial support.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

References

AOAC, 2000. Official Methods of Analysis, 17th ed. (Association of Official Analytical Chemists: Washington DC, USA).

Bhandari, S.K., Ominski, K.H., Wittenberg, K.M. and Plaizier, J.C., 2007. Effects of chop length of alfalfa and corn silage on milk production and rumen fermentation of dairy cows. Journal of Dairy Science. 90, 2355–2366.

Conway, E.J., 1962. Microdiffusion Analysis and Volumetric Error, 5th ed. (Crosby Lockwood: London).

General Laboratory Procedure, 1966. Report of Dairy Science. (University of Wisconsin Madison: USA).

Latif, S. and Mueller, J., 2015. Potential of cassava leaves in human nutrition: a review. Trends in Food Science and Technology. 44, 147–158.

Nguyen, T.H.L., Ngoan, L.D., Bosch, G., Verstegen, M.W.A. and Hendricks, W.H., 2012. Ileal and total tract apparent crude protein and amino acid digestibility of ensiled and dried cassava leaves and sweet potato vines in growing pig. Animal Feed Science Technology. 172, 171–179.

Ogimoto, K. and Imai, S., 1981. Atlas of Rumen Microbiology. (Japan Scientific Society Pr: Tokyo).

Ramos, S., Tejido, M.L., Martinez, M.E., Ranilla, M.J. and Carro, M.D., 2009. Microbial protein synthesis, ruminal digestion, microbial population, and nitrogen balance in sheep fed diets varying in forage-to-concentrate ratio and type of forage. Journal of Animal Science. 87, 2924–2934.

Reed, J.D., McDowell, R.E., Van Soest, P.J. and Horvath, P.J., 1982. Condensed tannins: a factor limiting the use of cassava forage. Journal of the Science of Food and Agriculture. 33, 213–220.

Rodriguez, M.A.B., Sanchez, F.J.S., Castro, C.A.S., Klieve, A., Herrera, R.A.R., Poot, E.G.B. and Ku-Vera, J.C., 2015. Rumen function in vivo and in vitro in sheep fed *Leucaena leucocephala.* Tropical Animal Health and Production. 47, 757–764.

Soto-Blanco, B. and Gorniak, S.L., 2010. Toxic effects of prolonged administration of leaves of cassava (*Manihot esculenta* Crantz) to goats. Experimental and Toxicology Pathology. 62, 361–366.

Zhao, X.G., Wang, M., Tan, Z.L., Tang, S.X., Sun, Z.H., Zhou, C.S. and Han, X.F., 2009. Effects of rice straw particle size on chewing activity, feed intake, rumen fermentation and digestion in goats. Asian-Australian Journal of Animal Science. 22, 1256–1266.