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Full Length Research Paper

Utilisation of Melastoma (*Melastoma affine,* D. Don) foliage as a forage for growing goats with cassava *(Manihot esculenta,* Crantz) hay supplementation

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Twenty-four weaned crossbred male goats (Bachthao x local female) with initial live weights of 9.9 (0.73) kg were used in an experiment to evaluate the effect of four different diets on intake. The diets were composed of *Melastoma affine* foliage fed *ad libitum* supplemented with cassava hay at four levels: 0, 15, 30 and 45% of an expected dry matter (DM) intake of 3% of body weight (BW). Cassava chips were added to all diets in the same amount, 70 g DM/goat/day and the experiment lasted 90 days. Feed intake, crude protein (CP) intake, and also live weight gain on the diet without cassava hay supplement was lowest (2.5% of BW, 26 and 6 g/day, respectively). The goats consuming 300 g Melastoma/kg DM had the highest feed intake and daily weight gain (2.8% of BW and 48 g/day, respectively). In digestible experiment, the digestibility of CP was significantly higher in the diet consisting of 450 g cassava hay/kg DM as compared to the Melastoma foliage diet without cassava hay supplement. Feeding Melastoma foliage and cassava hay decreased the number of Nematoda eggs and Coccidia oocysts in the faeces. In conclusion, goats consuming a diet containing 480 g cassava hay and 300 g Melastoma foliage per kg DM had the highest intake of DM and CP, the highest daily weight gain and the lowest number of parasite eggs in the faeces.

Key words: Melastoma affine foliage, cassava hay, digestibility, feed intake, growth, goats, parasites.

INTRODUCTION

In the Mekong delta of Vietnam, animal production is concentrated to small farms, and is an important component, indispensable to the integrated farming systems for utilising locally available resources and generating incomes (Xuan and Sanh, 1998). Shortages of feed resources are often a constraint for development of animal production in the tropics and subtropics (Aregheore, 2000). *Melastoma affine,* a shrub that can grow to about 2 m height, is abundant in natural conditions and has promising properties as a feed for goats e.g. is available locally, drought tolerant, and especially well adapted to lowlands and acid sulphate soil areas. However, Melastoma is not presently being considered as a potential feed by local goat keepers and/ or researchers. According to McDonald et al. (1992), evaluating intake of tropical forages is important when deciding the feeding value, as a high feed consumption creates the necessary conditions for an increase in production. Melastoma foliage has a low nutritive value with 108 g crude protein (CP) and 249 g crude fibre per kg dry matter (DM). The DM content is relatively high, 252 g/kg (Dung, 1996).

In Vietnam, cassava *(Manihot esculenta,* Crantz) is the second most important crop after rice in the small farm sector, cultivated on about 250,000 ha with a total production of 3 million tonnes per year (Van et al., 2001).

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There is also a large amount of foliage (leaves and young stems) readily available as a by-product at the time of harvesting the roots. Cassava hay made by sun drying contained a high level of CP (250 g/kg DM) and low levels of HCN, NDF and ADF (Wanapat et al., 1997). Cassava root chips are used as an energy source in animal diets. They contain 880 to 900 g DM/kg, 23 to 25 g CP and 760 to 810 g soluble carbohydrate per kg DM (Gomez and Waldivieso, 1983), which consists of 640 to 720 g starch, the remainder being sugars; sucrose, maltose, glucose, and fructose. According to Sathapanasiri et al. (1990), the starch of cassava is highly degraded in the rumen and completely digested in the whole tract. The objective of these studies was to determine whether Melastoma foliage as a basal diet with a supplementation of cassava hay and cassava root chips can satisfy the requirements for goats of 10 to 12 kg growing 50 g/day.

MATERIALS AND METHODS

Location and climate of the study area

The experiments were carried out at Cantho University Research Farm, Campus II (10°01'N, 105°45'E), Cantho City, Vietnam. In this area the climate is monsoon tropical with a wet season between May and November and a dry season between December and April. Annual rainfall varies from 1400 to 2400 mm and the mean temperature is 26.6°C.

Experimental feeds

The feeds used in the experiments were foliage from *M. affine*, cassava hay and cassava chips. Melastoma foliage was collected every second day from Hoaan research station from the fallow land or from the boundaries of the arable land around the station. Young stems with leaves, around 40 cm length and 0.2 to 0.5 cm in diameter that are acceptable to goats were selected. Cassava foliage for making cassava hay was bought from the farmers at the harvest of tubers at an age of 8 months, chopped into pieces of 2 to 3 cm manually, and dried in the sun for 4 to 5 days and then stored in plastic bags of about 20 kg.

Cassava chips were made from cassava roots. After harvesting, the roots were cleaned, chopped by hand or by machine into small pieces and sun-dried for 3 days and then stored in plastic bags of about 20 kg. Cassava chips were also bought from the farmers. A homemade mineral lick containing 50% steamed bone meal and shell meal (1:1), 10% commercial trace mineral mix, 5% molasses, 10% cement as a binding agent and 25% NaCl was placed inside each individual cage, and was available at all times.

Experimental animals and management

In the growth trial, twenty-four weaned crossbred male goats (Bachthao x local female) with an initial weight of 9.9 (0.73) kg and 3 to 4 months old were used. In the digestibility study, another four male weaned crossbred goats (Bachthao x local female) with an initial weight of 10.1 (0.74) kg, and 3 to 4 months of age were used. The experimental goats were housed in individual pens, de-wormed with Ivermectine, vaccinated against foot-and-mouth disease and gradually introduced to the experimental feeds for 10 days for adaptation. Melastoma foliage was hung in bunches above the fodder trough. Cassava hay was fed in plastic troughs for goats to choose freely. Amounts offered were decided weekly based on individual weight (cassava hay) and average daily consumption the previous week (Melastoma foliage).

For the cassava hay, the total feed intake was estimated at 3% of body weight, based on the DM content of the feeds and the offer for the different treatments were calculated as a percentage of this. The Melastoma foliage was fed at 130% of the individual average daily intake of the previous week. Feed offered for each goat was weighed every morning and the animals were given 50% of their daily ration at 08:00 h in the morning and 50% at 14:00 h in the afternoon. Cassava chips were added to the diets in the same amount, 70 g DM/goat/day, as a supplementary energy source. Fresh water and mineral lick were supplied *ad libitum.* The goat house and individual cages were cleaned daily in the morning before feeding. The nutrient requirements for goats were estimated to be 23.2 g digestible protein, and 3.99 MJ ME/day for a goat of 10 kg with a daily live weight gain of 50 g/day, and a DM intake of 3% of body weight (Devendra and McLeroy, 1982).

Experimental design

The growth experiment had a Completely Randomized Design (CRD) with 4 treatments (diets) and 6 goats per treatment. The experiment lasted for 90 days. The animals were randomly allocated to the diets and to the pens. All 4 diets contained Melastoma foliage *ad lib* and 70 g DM cassava chips. The diets were supplemented with 0, 15, 30 or 45% cassava hay (% of estimated DM intake, which was 3% of BW).

The digestibility study had a Latin-square design, 4 x 4 arrangements with 4 animals, 4 periods, and 4 diets, the same diets as in the growth experiment. This trial lasted for 93 days, 4 periods consisting of 14 days of adaptation and 7 days of collection of faeces and urine, and 3 days for releasing the animals to move freely between periods.

Data collection

Melastoma foliage, divided into leaves+petioles and stems, cassava hay and cassava chips were initially analysed for DM, CP, neutral detergent fiber (NDF), acid detergent fiber (ADF) and ash before the start of the experiments. The foliage and the cassava hay were analysed for condensed tannins. In the growth study, DM determination of Melastoma foliage was done once a week to adjust the diets. Feed refusals (Melastoma leaves+petioles and stem and cassava hay) were separately collected from individual animals, weighed every morning and pooled per week and treatment group and analysed for DM, CP, NDF, ADF, ash and condensed tannins. The animals were weighed at the start of the experiment and then weekly, at the same day of the week and before feeding in the morning. Daily health and feeding behaviour of goats were monitored by observation. The experiment was started 10 days after drenching against internal and external parasites.

Faecal samples were taken directly from rectum at four occasions, at the beginning of the experiment and after 30, 60 and 90 days. The samples were stored in plastic bags in a refrigerator (4°C) before counting eggs per g faeces (EPG) to prevent physical and chemical changes and hatching, which may cause problems when counting. Nematoda and Cestoda eggs and Coccidia oocysts were recorded using a McMaster counting chamber. 4 g of faecal samples were ground and mixed with 56 ml of flotation fluid (a saturated salt solution in water). After filtering through a "tea strainer", a sub-sample was transferred to both compartments of a McMaster counting chamber and allowed to stand for 5 min. All helminth eggs were counted under a microscope at 10x magnification and multiplied by 50 to yield the EPG of faeces (Hansen and Perry, 1994).

Table 1. Chemical composition of the experimental feeds (means and standard deviation (SD)).

Item	Melastoma stems	Melastoma leaves	Cassava chips	Cassava hay
Dry matter (g/kg)	271 (22)	280 (21)	872 (8)	849 (9)
Dry matter (g/kg)				
Ash	72 (11)	89 (8)	25 (0.5)	87 (3)
Crude protein (CP)	44 (4)	114 (9)	44 (1)	241 (2)
Neutral detergent fiber (NDF)	539 (27)	290 (21)	75 (3)	312 (46)
Acid detergent fiber (ADF)	407 (22)	246 (18)	47 (1)	263 (43)
Tannin	63 (7)	98 (8)	2 (0.1)	37 (14)
Number of samples	10	10	6	6

During the digestibility experiment, DM determination was done twice per period to adjust the diets. During the sample collection period, feed refusals (Melastoma foliage (divided into fractions) cassava hay, cassava chips), faeces, and urine were taken from individual animals, weighed every morning and pooled for 7 days to provide a representative sample for each goat and analysed for DM, CP, NDF, ADF and ash. The animals were weighed before commencement of the adaptation period and before feeding in the morning on the first and last day of each collection period.

Chemical analysis

For chemical analysis, the DM, CP and ash were determined according to AOAC (1990). The CP content of feedstuffs, refusals, fresh faeces, and urine were analysed by the Kjeldahl method and CP was calculated as N×6.25. Ash was assayed by incinerating samples at 600°C. The content of NDF and ADF was determined according to Van Soest and Robertson (1985), using sodium sulphate and amylase and was expressed with residual ash. Condensed tannins were determined according to AOAC (2000).

Statistical analysis

The data were analyzed statistically by an analysis of variance using the General Linear Model (GLM) procedure of Minitab Software Release version 13.1 (Minitab, 2000). When the differences in treatment means were significant at the probability level of $P<0.05$ or 0.01, the means were compared by using Tukey's pairwise test. The statistical model used for the growth experiment was:

$$Y_{ij} = \mu + T_j + \beta X_{ij} + e_{ij}$$

Where Y_{ij} = the dependent variable, μ = overall mean, T_j = effect of treatment, and e_{ij} = random error.

The initial weight X was used as a covariate. The slope βXij describes the change in the response Y when the covariate X increases one unit. The statistical model used for the digestibility study was:

$$Y_{ijk} = \mu + A_i + B_j + C_k + e_{ijk}$$

where Y_{ijk} = dependent variable, μ = overall mean, A_i = effect of diets, B_j = effect of animal, C_k = effect of periods and e_{ijk} = random error. The data for parasitic egg counts were transformed by the power of logarithms prior to analysis.

RESULTS

Melastoma stems and cassava chip (Table 1) had a similar CP content, only 44 g/kg DM, while the leaves of Melastoma had a higher level of CP, 114 g/kg DM. The DM content of Melastoma leaves was slightly higher than Melastoma stems. There were only low variations in DM and CP content during the experiment. The NDF and ADF of Melastoma leaves were rather low in comparison to Melastoma stems and cassava hay. The cassava hay had a high level of CP, 241 g/kg DM. Most of the cassava root and the cassava hay offered were consumed, even in the group with the highest level of supplementation. In the growth trial, the effect of different levels of cassava hay supplement on feed intake is given in Table 2. Total DM intake, average DM intake in percent of BW, and also intake of DM related to metabolic body weight ($W^{0.75}$) were significantly lower for the diet without cassava hay supplement than for the diets containing cassava hay, but there were no significant differences between the different levels of cassava supplement. When the level of cassava hay in the diet increased the intake of cassava hay increased and intake of Melastoma decreased to a corresponding level, so total DM intake in all groups fed cassava hay was similar. The CP intake, both total and per kg $W^{0.75}$ increased significantly with increasing levels of cassava hay supplement.

Changes in live weight gain (LWG) during the experiment are presented in Table 3. The diets containing 620 and 790 g/kg DM of Melastoma resulted in a significantly lower daily weight gain as compared to 300 g and 450 g/kg DM of Melastoma. The goats fed the diet with 300 g/kg DM of Melastoma showed the significantly highest daily gain and the lowest feed conversion ratio (FCR) for protein. In the digestibility experiment (Table 5), there was a significant increase in total intake of DM, OM and CP when using Melastoma foliage as a basal diet with a cassava hay supplement. The digestibility of CP was significantly highest in the diet containing 45% cassava hay as compared to the basal Melastoma foliage diet without cassava hay supplement.

All diets resulted in a positive N-balance. The effect of

Table 2. Feed offered and feed intake during the experiment (Least Squares means (LS-means) and standard error (SE)).

Item	Experimental diet				
	CH0	CH15	CH30	CH45	SE
Feed offered (g DM/day)					
Cassava hay	0	54	109	163	
Cassava chip	70	70	70	70	
Melastoma					
Leaves	238	202	166	131	
Stems	155	132	109	86	
Total	464	459	454	449	
Feed intake (g DM/day)					
Cassava hay	0^{d}	52^{c}	104^{b}	153^{a}	0.5
Cassava chip	60^{c}	68^{ab}	69^{a}	67^{b}	0.5
Melastoma					
Leaves	179^{a}	158^{b}	123^{c}	90^{d}	0.9
Stems	48^{a}	35^{b}	19^{c}	8^{d}	0.6
Total	288^{b}	313^{a}	314^{a}	317^{a}	1.3
% Melastoma of total DM	79^{a}	62^{b}	45^{c}	30^{d}	0.3
% Cassava hay of total DM	0^{d}	17^{c}	33^{b}	48^{a}	0.1
Nutrient intake (g/day)					
OM	266^{b}	290^{a}	291^{a}	293^{a}	1.2
CP	26^{d}	36^{c}	43^{b}	52^{a}	0.2
NDF	67^{c}	71^{a}	70^{ab}	68^{bc}	0.6
ADF	57^{c}	61^{a}	60^{ab}	60^{b}	0.4
DM intake (% of BW)	2.5^{b}	2.7^{a}	2.8^{a}	2.8^{a}	0.1
DM intake (g/kg $W^{0.75}$)	46^{b}	50^{a}	51^{a}	51^{a}	0.2
CP (g/kg $W^{0.75}$)	4.1^{d}	5.7^{c}	6.9^{b}	8.3^{a}	0.1

^{a,b,c,d}Means within rows with different superscripts are significantly different (P<0.05); CH0, CH15, CH30, CH45 = 0, 15, 30 or 45% of 3% of BW of cassava hay on DM basis.

Table 3. Effect of diets on daily live weigh gain (LWG) and feed conversion ratio (FCR) (LS-means and SE).

Item	Experimental diet				
	CH0	CH15	CH30	CH45	SE
Initial weight (kg)	10.4	9.6	9.6	10.2	0.3
Final weight (kg)	10.9^{b}	11.0^{b}	13.8^{a}	14.5^{a}	0.3
LWG (g/day)	6^{c}	14^{b}	46^{a}	48^{a}	1.5
FCR (kg DM/kg LWG)	54.1^{a}	22.3^{b}	6.9^{c}	6.7^{c}	0.3
FCR (kg CP/kg LWG)	4.86^{a}	2.53^{b}	0.94^{d}	1.10^{c}	0.03

^{a,b,c,d}Means within rows with different superscripts are significantly different (P<0.05); CH0, CH15, CH30, CH45= 0, 15, 30 or 45% of 3% of BW of cassava hay on DM basis.

experimental diet on the number of Nematoda and Coccidia oocysts in the faeces of goats is shown in Table 4. Nematoda eggs and Coccidia oocysts decreased in most of the treatments after 1, 2 and 3 months of the study. The number of eggs in the faeces was only about 50% after 3 months compared to the initial. There was, however, no significant difference between the experimental diets. No Cestoda eggs were found in the faeces.

Table 4. Effect of diet on number of Nematoda eggs and Coccidia oocysts in the faeces of goats (LS-means).

Item	Experimental diets			
	CH0	CH15	CH30	CH45
Nematodes (eggs/g/faeces)				
Initial	194	200	244	237
30 days	150	148	190	133
60 days	122	107	134	146
90 days	106	86	104	124
After 90 days compared to initial (%)	54.7	42.8	42.6	52.7
Coccidia oocysts/g/faeces				
Initial	1469	1968	2099	1309
30 days	1125	1040	1656	1409
60 days	1259	993	1412	1352
90 days	738	966	794	772
After 90 days compared to initial (%)	50.5	48.9	37.9	63.2

CH0, CH15, CH30, CH45= 0, 15, 30 or 45% of 3% of BW of cassava hay on DM basis.

Table 5. Digestibility experiment: Feed offered, feed intake, digestibility and nitrogen utilisation during the experiment (LS-means and SE).

Item	Experimental diets				
	CH0	CH15	CH30	CH45	SE
Feed offered (g DM/day)	461	456	452	447	
Feed intake (g DM/day)	203^{b}	269^{a}	298^{a}	292^{a}	8.2
Nutrient intake (g/day)					
OM	184^{b}	256^{a}	268^{a}	271^{a}	6.5
CP	19^{d}	31^{c}	41^{b}	50^{a}	1.2
NDF	62^{b}	62^{b}	81^{a}	77^{a}	2.8
ADF	55^{ab}	54^{b}	72^{a}	64^{ab}	3.7
Digestibility (%)					
DM	50.2^{b}	57.6^{ab}	63.2^{a}	61.9^{ab}	2.6
OM	52.9	57.2	63.2	63.9	2.4
CP	23.1^{b}	40.4^{ab}	51.9^{ab}	57.2^{a}	6.1
NDF	50.7	46.9	45.4	44.1	3.9
ADF	46.1	40.9	43.5	39.0	3.3
N-balance (g/day)					
N-feed (g)	3.02^{d}	4.89^{c}	6.60^{b}	8.06^{a}	0.18
N-faeces (g)	2.28	2.94	3.19	3.45	0.25
N-urine (g)	0.62^{c}	0.85^{bc}	1.08^{ab}	1.23^{a}	0.07
N-retained (g)	0.11^{b}	1.10^{b}	2.33^{b}	3.38^{a}	0.25
Percentage of N intake					
N-faeces	76.9^{a}	59.7^{ab}	48.1^{ab}	42.8^{b}	6.1
N-urine	20.3	17.9	16.5	15.3	2.2
N-retention	2.8^{b}	22.5^{ab}	35.4^{a}	41.9^{a}	5.9

^{a,b,c,d}Means within rows with different superscripts are significantly different (P<0.05); CH0, CH15, CH30, CH45= 0, 15, 30 or 45% of 3% of BW of cassava hay on DM basis.

DISCUSSION

The CP content of Melastoma foliage was lower than found by Dung (1996). Comparison with some other foliages such as *Leucaena leucocephala, Hibiscus rosa – sinensis, Ceiba pentadra, Trichanthera gigantea* (Ba and Ngoan, 2003; Nhan, 2000) showed that the DM content of Melastoma foliage was higher but CP content was lower than in these foliages. Supplementation of cassava hay did not have a significant effect on total DM intake, the average DM intake in percent of BW and DM intake per $W^{0.75}$. This result is in agreement with Devendra and McLeroy (1982), who stated that DM intake seldom exceed 30 g/kg BW for meat goats in the tropics. The DM intake of the treatment without cassava hay supplement was significantly lower than the other diets, probably due to the fact that Melastoma foliage had a high content of condensed tannins. According to Silanikove et al. (1997) goats fed tannin rich foliages as their basal diet decreased the basal diet intake when supplemented with low protein concentrates, whereas high protein supplements stimulated basal diet intake.

The CP intake and daily weight gain increased significantly with decreasing percent of Melastoma of total DM consumed. Preston and Leng (1987) have strongly emphasized the importance of protein intake as the determinant of performance in ruminants. Minson (1981) pointed out that low levels of high quality protein lead to low voluntary feed intake, an imbalance in the absorbed nutrients, and as a consequence, growth is reduced. The significantly highest live weight gain and the lowest feed conversion ratio were obtained with the diet with the highest level of cassava hay and 300 g of Melastoma per kg total DM consumed. Ho and Preston (2006) and Vanthong and Preston (2011), stated that goats supplemented with cassava foliage had a faster growth rate. This live weight change was still lower than compared to what has been obtained in goats fed *L. leucocephala, H. rosa-sinensis*, and *C. pentadra,* according to Nhan (2000). The present experiment is in agreement with the result of Devendra (1993), and Stewart and Simons (1994), who reported that, when used as supplements, the optimum dietary level of fodder trees and shrubs should be about 300 to 500 g/kg DM of the ration. Jones (1979) and Reed et al. (1990) suggested that supplements of fodder tree leaves should be about 300 g/kg diet DM, because of the secondary compounds which inhibit the digestibility and reduce the acceptability to the animals at higher levels of inclusion.

Also, Hao (1999) found that supplementing a basal diet of rice straw with 300 g Gliricidia/kg DM resulted in an increased intake of DM, OM and CP and the highest growth rate, 105 g/day. High feeding levels of Jackfruit lead to low daily gain (Mui, 2001; Kibria et al., 1994). The low digestibility of CP of the basal Melastoma foliage diet without cassava hay supplement was probably due to the presence of greater quantities of condensed tannin, which may have inhibited the activities of rumen microbes. This result agrees with Feeny (1976) and Rhodes and Cates (1976), who concluded that tannins reduce the digestibility of nutrients. It could also be that at low levels of CP, the endogenous CP is more important and constitutes a greater part of the CP in faeces. The data for parasitic egg counts implies that both Melastoma foliage and cassava hay contain condensed soluble tannins that have an anthelmintic effect against Nematoda eggs and Coccidia oocysts. This result is supported by many reports (Seng and Rodriguez, 2001; Seng, 2003; Dung, 2003). Goats fed both fresh and ensiled cassava foliage had reduced worm fecundity (Seng et al., 2009).

According to Duncan (1996) and Netpana et al. (2001), condensed tannins also inhibit the viability of sheep, cattle and buffalo nematode parasites. However, in general the levels of parasite eggs were low, probably depending on treatment before the experiment started in combination with pen feeding. Even though there is no significant difference between the different ratios of Melastoma and cassava hay the results suggest that the diet with 33% cassava hay and 45% Melastoma was the most effective mixture.

Conclusions

The results of the present studies indicate that Melastoma foliage at the level of 300 g/kg DM can in combination with a high protein feed like cassava hay give acceptable growth rates for growing goats. The foliage of *M. affine*, although only sufficient for low growth rates, can still play an important role in solving the shortage of grass on poor soils and in a dry zone.

Both Melastoma foliage and cassava hay contained condensed tannins, which resulted in decreased number of Nematoda eggs and Coccidia oocysts in the goats. Possibly a feed with a lower content of tannins than cassava hay would be better as a supplement in diets based on Melastoma foliage for growing goats.

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