Study on Nutritive Value of Tropical Forages in North Sumatra, Indonesia

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ABSTRACT : This study was conducted to evaluate nutritive value of forages commonly used as ruminant feeds in North Sumatra, Indonesia. Seven species of grasses and five species of legumes were collected during the rainy season. The results showed that chemical composition, *in vitro* digestibility of dry matter (DMD), organic matter (OMD) and crude protein (CPD), *in vitro* gas production and metabolizable energy (ME) content greatly varied among the species of grass and legume forages. The CP content ranged from 6.6 to 16.2% in grass and from 17.5 to 29.1% in legumes; while NDF content of grass and legume ranged from 57.2 to 66.2% and from 24.4 to 55.6%, respectively. The DMD, OMD and CPD of grass ranged from 49.1 to 62.2%, 51.9 to 64.4% and 50.5 to 60.3%; while in legumes the values ranged from 59.1 to 71.8%, 65.2 to 72.0% and 68.2 to 71.6%, respectively. The ME content of grass varied from 6.4 to 9.3 MJ/kg and from 6.5 to 8.3 MJ/kg for legumes. In general, within species of grass *Cynodon plectostachyus* contained higher CP but was lower in NDF that resulted in much higher digestibility; a similar result was also found in *Leucaena leucocephala* for the legumes. The two forages also contained much higher ME than the others. In conclusion, the nutritive value of forages in North Sumatra, Indonesia during the rainy season was relatively high as ruminant feed, with the best quality noted for *Cynodon plectostachyus* and *Leucaena leucocephala*. ***(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 11 : 1518-1523)***

Key Words : Forages, Nutrient Content, *In vitro* Digestibility, Gas Production, Metabolizable Energy

INTRODUCTION

In North Sumatra as well as in other parts of Indonesia, sheep and goats are commonly raised by small farmers in rural areas under traditional systems with native forages, tree leaves and agriculture by- products as main sources of feeds. Less than one percent of animals are raised under fully commercialized conditions. An inadequate yearly supply of good quality forage is common in Indonesia. A very wide variation in both quantity and quality of the forages fed to ruminants depends upon areas, season, soil fertility, fertilizer application and harvesting time (maturity). Norton and Poppi (1995) suggested that differences in nutritive value between plant species are largely attributable to difference in their anatomy, biochemistry and morphology.

The use of *in vitro* digestion and gas production technique is rapidly expanding because of an increased need for routine and reproducible methods to obtain data on bio-availability of feeds in addition to chemical composition (Blümmel and Ørskov, 1993). *In vitro* gas production proposed by Menke and Steingass (1988) has been used for estimation of organic matter digestibility, metabolizable energy and nutrients availability of feedstuffs. Limited information exists concerning nutritive value of forages in North Sumatra. Therefore, the present experiment was aimed at evaluatinge the nutritive value of forages through measurement of chemical composition, *in vitro* digestibility, *in vitro* gas production and metabolizable energy content.

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MATERIALS AND METHODS

Experimental site

This study was conducted in Medan (North Sumatra), Indonesia. The province is located in the tropical and monsoon region, and lies between 98-100° East and 1-4° N. There are two seasons during the year, dry season from February to September and rainy season from November to March. The temperature is nearly constant, differing by only a few degrees among the dry and rainy seasons with daily temperature ranges from 18 to 34°C. The annual rainfall ranges from 1,100 to 3,400 mm with humidity varying between 79 to 96%.

Collection of forage samples

The forages evaluated consisted of seven species of grasses (*Andropogon gayanus, Axonopus compressus, Brachiaria decumbens, Cynodon plectostachyus, Panicum maximum, Pennisetum purpuphoides* and *Pennisetum purpureum*) and 5 species of legumes (*Calopogonium mucunoides, Centrosema pubescens, Gliricidia maculata, Leucaena leucocephala* and *Pueraria phaseloides*). The forage samples were collected during the rainy season

Table 1. Chemical composition of grass and legume species (% DM)

Forage species	OM	CP	EE	NDF	ADF	ADL
Grass						
A. gayanus	89.3 [ab]	6.6 [a]	2.7 [a]	59.3 [a]	41.5 [d]	5.9 [c]
A. compressus	88.0 [a]	10.6 [b]	3.9 [c]	58.0 [a]	38.2 [c]	6.9 [d]
B. decumbens	89.1 [ab]	12.8 [bc]	2.9 [ab]	57.8 [a]	32.1 [a]	5.4 [bc]
C. plectostachyus	89.1 [ab]	16.2 [d]	3.2 [bc]	57.2 [a]	36.8 [bc]	6.7 [d]
P. maximum	90.2 [b]	15.1 [d]	2.7 [a]	62.7 [b]	47.3 [e]	3.6 [a]
P. purpuphoides	88.8 [ab]	15.2 [d]	2.7 [a]	63.4 [b]	35.6 [b]	6.5 [d]
P. purpureum	89.9 [ab]	14.4 [cd]	2.7 [a]	66.2 [c]	40.6 [d]	3.7 [a]
Mean±SEM	89.2±0.15	13.0±0.71	3.0±0.11	62.1±0.39	38.9±1.07	5.5±0.23
Legume						
C. mucunoides	89.6 [b]	18.3 [a]	3.4 [a]	55.6 [e]	33.9 [c]	6.8 [c]
C. pubescens	89.1 [b]	18.9 [a]	2.8 [a]	51.1 [d]	43.1 [d]	4.7 [a]
G. maculata	87.3 [a]	17.5 [a]	3.8 [bc]	40.7 [b]	27.1 [b]	6.5 [c]
L. leucocephala	88.6 [ab]	29.1 [c]	4.6 [d]	24.4 [a]	20.1 [a]	4.9 [ab]
P. phaseloides	89.9 [b]	23.2 [b]	4.3 [cd]	46.3 [c]	28.4 [b]	5.4 [b]
Mean±SEM	88.9±0.26	21.6±1.19	3.9±0.20	42.7±2.01	29.6±2.07	5.7±0.30
Significant diff. of grass×legume	NS	**	*	**	**	NS

[a, b, c] Values with different superscripts in the same column within the species of grass or legume differ significantly ($p<0.05$).
NS: Non significant; * $p<0.05$; ** $p<0.01$. SEM: Standard error of the mean.

(November, January, March). The grass and legume samples were oven dried at 60°C for 48 h and coarsely milled to pass a 1 mm screen for further analyses. Chemical composition of the forages were analyzed by the standard method of the Association of Official Analytical Chemist (AOAC, 1984); while NDF, ADF and acid detergent lignin (ADL) contents were determined according to the procedures of Goering and Van Soest (1970).

Determination of *in vitro* digestibility, gas production and metabolizable energy content

In vitro digestibility of dry matter (DMD), organic matter (OMD) and crude protein (CPD) of the forages were determined by the methods of Tilley and Terry (1963) and Goering and Van Soest (1973). The rumen fluid for measurement of *in vitro* digestibility and gas production was taken from healthy mature Japanese Corriedale sheep fitted with permanent rumen cannulae (Ø=70 mm). One part of the rumen fluid was mixed with two parts of the medium consisting of buffer solution, macro and micro mineral solutions, resazurine and reduction solution. One gram of each sample was incubated in the rumen fluid-buffer medium mixture through water shaker bath at 39±0.1°C for 96 h. After finishing the *in vitro* digestion trials, all the incubated materials were filtered and dried at 60°C for 96 h to determine DMD. The residues were analyzed for crude protein (CP) and organic matter (OM) to determine OMD and CPD.

In vitro gas production was measured with syringes according to the method described by Menke and Steingass, 1988). The produced gas was read at a series of incubation times, i.e. 3, 6, 12, 24, 48, 72 and 96 h. The exponential equation proposed by Ørskov and McDonald (1979) was used to determine characteristics of gas production using Neway-Exel computer program (Macaulay Institute, Aberdeen, UK). The equation was: $p=a+b\ (1-e^{-ct})$, where: p=the volume of gas production; a=intercept of gas production curve; b=asymptote and c=the rate of gas production (ml/h). The value of (a+b) represented the potential extent of *in vitro* gas production. Metabolizable energy (ME) content of the forages was estimated according to the following equation (Menke and Steingass, 1988): ME (MJ/kg DM)=$2.2+0.136\ (GP_{24h})+0.0057\ (CP)+0.00029\ (EE)^2$, where: ME=metabolizable energy; GP=gas production at 24 h incubation time; CP=crude protein content (g/kg) and EE=ether extract (crude fat) content of the forage (g/kg).

Statistical analysis

Data of the chemical composition, *in vitro* digestibility, *in vitro* gas production and ME content were analyzed using General Linear Model (GLM) procedure for computations of means and standard errors according to SAS/Statview® (1999). Differences of the means within species of grass or legume and between grass and legume were compared using probability of difference. The following statistical model was used in the analysis: $Y_{ij}=\mu+S_i+e_{ij}$, Where: Y_{ij}=dependent variable (general observation); μ=the overall mean; S_i=effect of i^{th} species (i=1, 2……, 7 in grasses; i=1, 2……, 5 in legumes), and e_{ij}=residual error of the dependent variable.

RESULTS AND DISCUSSION

Chemical composition

Table 1 shows chemical composition of forages. There

Table 2. *In vitro* digestibility of dry matter, organic matter and crude protein of forages (%)

Forage species	DMD[#]	OMD[#]	CPD[#]
Grass			
A. gayanus	49.9±2.1[a]	51.9±0.8[a]	50.5±0.2[a]
A. compressus	56.2±0.9[b]	56.7±2.4[b]	56.9±1.4[b]
B. decumbens	56.2±1.8[b]	57.2±1.0[b]	58.1±0.6b[c]
C. plectostachyus	62.2±2.4[c]	64.4±2.7[c]	60.1±0.8[c]
P. maximum	56.1±1.9[b]	55.6±2.6[b]	60.3±1.2[c]
P. purpuphoides	54.2±0.8[b]	54.5±1.2[ab]	55.2±0.2[b]
P. purpureum	56.3±2.9[b]	62.7±1.3[c]	58.6±0.2[bc]
Mean±SEM	55.9±1.84	57.6±1.84	57.1±0.66
Legume			
C. mucunoides	59.1±0.6[a]	65.2±0.3[a]	67.2±0.8[a]
C. pubescens	60.8±0.5[a]	68.6±0.1[ab]	68.5±0.8[ab]
G. maculata	66.8±0.7[b]	65.7±2.1[a]	68.2±2.5[ab]
L. leucocephala	71.8±2.1[c]	70.5±2.0[bc]	71.6±0.1[b]
P. phaseloides	69.7±1.6[bc]	72.0±1.2[c]	70.1±1.1[b]
Mean±SEM	65.6±1.09	68.4±0.91	69.2±1.07
Significant diff. of grass×legume	**	**	**

[#] 96 h incubation time.

[a, b, c] Values with different superscripts in the same column within the species of grass or legume differ significant ($p<0.05$).

** $p<0.01$.

SEM: Standard error of the mean.

were great variations among the plant species for OM, CP, ether extract (EE), NDF, ADF and ADL contents. The CP content of grasses varied from 6.6% in *A. gayanus* to 16.2% in *C. plectostachyus*, while OM ranged from 88.0 (*A. compressus*) to 90.2% (*P. maximum*). The CP content of the grass in the present study was relatively higher compared to the CP content of several grasses in South Sumatra that varied from 7.6 to 10.2% (Fariani, 1996). However, it was very comparable with the study of Tudsri et al. (2002); Ammar et al. (1999); Nasrullah et al. (2002) and Yahaya et al. (2002) who obtained the CP content of several tropical grasses (6.3 to 16.8%). Minson (1990) showed that CP content of 560 tropical forages at different parts of the world ranged from 2 to 27%. The grasses contained a wide variation of fiber component; NDF content ranged from 57.2% (*C. plectostachyus*) to 66.2% (*P. purpureum*), ADF from 32.1% (*B. decumbens*) to 47.3% (*P. maximum*) and ADL from 3.6% (*P. maximum*) to 6.9% (*A. compressus*). Ammar et al. (1999) obtained that NDF, ADF and ADL contents of grasses harvested at different stages of maturity ranged from 56.8 to 68.9%; 25.7 to 38.3% and 1.6 to 5.8%, respectively. While NDF, ADF and ADL contents of commonly grasses in South Sumatra varied from 7.6 to 10.2%; 66.3 to 72.3%; 36.7 to 41.4%; 3.9 to 6.4%, respectively (Fariani, 1996).

It has been widely reported that legumes contained higher CP content but were lower in NDF and ADF than grasses. As shown in Table 1, the CP content of legumes varied from 17.5 (*G. maculata*) to 29.1% (*L. leucocephala*). This finding was similar to the CP content of tropical legumes (9.4 to 29.9%) as shown by Norton (1995), but it was slightly higher than the CP content of legumes in West Sumatra during rainy season (13.8 to 25.5%) (Evitayani et al., 2004) and with the CP content of legumes in South Sumatra (18.9 to 22.0%) (Fariani, 1996).

Data on fiber fractions showed that *L. leucocephala* contained relatively lower NDF, ADF and ADL (24.4, 20.1 and 4.9%), while *C. mucunoides* contained higher NDF and ADL (55.6 and 6.8%) compared to the other legumes. As expected, there was a negative relationship between CP and fiber content, in which low crude protein was associated with high fiber fractions. Ammar et al. (1999) reported that NDF, ADF and ADL contents of legumes harvested at different growth stages ranged from 32.3 to 47.4; 11.3 to 31% and 1.9 to 8.9%, respectively. Fariani (1996) showed that NDF, ADF and ADL contents did not significantly differ among the species of legumes harvested in South Sumatra, the values varied from 29.4 to 66.3%; 14.8 to 42.0%; 3.6 to 6.3%, respectively. It was suggested that the differences in chemical composition and fiber fractions of the forages evaluated in the present study with the other experiments could be caused by differences in species of grass or legumes observed, fertilizer application, soil fertility, growth stage and season. In general however, the legume forages contained higher amounts of CP but were lower in NDF and ADF compared with grass. Similar results were obtained for grasses and legumes in South Sulawesi, Indonesia (Nasrullah et al., 2003).

In vitro digestibility

Table 2 shows *in vitro* digestibility of dry matter, organic matter and crude protein of grasses and legumes. The DMD of grasses varied from 49.9 (*A. gayanus*) to 62.2% (*C. plectostachyus*). This finding agreed with the other results of DMD for tropical grasses (Laredo et al., 1973; Poppi et al., 1981); but it was relatively lower compared with the DMD values reported by Fariani (1996) and Ammar et al. (1999). The OMD of grasses ranged from 51.9 (*P. purpuphoides*) to 64.4% (*P. purpureum*). These values were relatively higher compared to the study of Noguiera (1999) who obtained OMD of tropical grasses ranged from 40.9 to 52.7%. However it was lower than the values obtained by Chapman (1986) and Rees (1982) who informed the OMD of tropical grasses varied from 61.2 to 69.6%. The CPD of grasses varied from 50.5 (*A. gayanus*) to 60.3 % (*C. plectostachyus*), and it was in the range of 30-70% CPD for other tropical forages (Milford and Haydock, 1965). It was suggested that differences in nutrient digestibility may be related to differences in chemical composition of the forages particularly in fiber, lignin and silica contents, forage species, soil fertility and other environmental factors. Generally, *C. plectostachyus* and *P.*

Table 3. *In vitro* gas production characteristics and estimated metabolizable energy content of grass and legume

Forages species	24 h	96 h	a+b[1]	c[2]	ME (MJ/kg DM)
Grass					
A. gayanus	24.9[a]	35.2[a]	38.3[a]	0.058[ab]	6.4[a]
A. compressus	21.1[a]	34.3[a]	39.4[a]	0.043[a]	6.4[a]
B. decumbens	24.0[a]	37.9[a]	37.3[a]	0.046[ab]	6.8[ab]
C. plectostachyus	46.1[d]	49.4[c]	49.4[c]	0.127[d]	9.3[c]
P. maximum	31.5[b]	42.4[b]	42.5[b]	0.062[bc]	7.9[b]
P. purpuphoides	34.5[bc]	43.9[b]	43.7[b]	0.075[c]	8.0[b]
P. purpureum	36.1[c]	48.2[c]	48.2[c]	0.065[bc]	8.5[b]
Mean±SEM	31.2±0.20	41.6±1.12	42.7±1.09	0.068±0.009	7.6±0.14
Legume					
C. mucunoides	26.2[a]	36.9[a]	37.0[a]	0.056[b]	7.1[ab]
C. pubescens	25.4[a]	35.6	35.8[a]	0.054[b]	6.5[a]
G. maculata	26.8[a]	40.5[b]	41.7[b]	0.047[a]	6.8[a]
L. leucocephala	30.6[b]	42.2[b]	41.7[b]	0.057[b]	8.3[c]
P. phaseloides	30.5[b]	40.9[b]	41.0[b]	0.060[b]	7.9[bc]
Mean±SEM	27.9±0.19	39.2±0.3	39.4±1.02	0.055±0.002	7.3±0.12
Significant diff. of grass×legume	*	NS	*	*	NS

[a, b, c] Values with different superscripts in the same column within the species of grass or legume differ significant ($p<0.05$).NS: Non siginificant. * $p<0.05$.
[1] Potential gas production (ml/200 mg DM).
[2] Production rate of constant (ml/h). SEM: Standard error of the mean.

purpureum contained relatively higher digestibility, while *B. decumbens* was lower compared to the other grasses.

In the legumes, DMD ranged from 59.1% (*C. mucunoides*) to 71.8% (*L. leucocephala*). OMD varied from 65.2% (*C. mucunoides*) to 72.0% (*P. phaseloides*) and CPD ranged from 67.2% (*C. mucunoides*) to 71.6% (*L. leucocephala*). Fariani (1996) reported that DMD of legumes in South Sumatra varied from 59.03 to 70.36% with the highest value was occurred in *L. leucocephala*. Several researchers have reported a wide variation in DMD of tropical legumes. the values were from 53.2-84.3% (Khamseekhiew et al., 2001), 67-83% (Ammar et al., 1999), 48.5 to 87.0% (Kimambo et al., 1994) and 72.1-86.7% (Apori et al., 1998). Digestibility of the legumes depends on the stage of maturity, leafiness, amount of petioles and stem, presence of toxic matter and species of animals (Singh, 1981). The high CP content and the fragility of legume cell walls, especially that of young vegetative material, resulted in high DMD (Ndlovu, 1991). According to Devendra (1995) the CPD varies considerably, and is associated with the CP and fiber contents, low CP and high fiber contents are usually associated with low digestibility. In the present study, *P. phaseloides* and *L. leucocephala* had relatively higher DMD, OMD and CPD than those of the other legumes. These findings were consistent with their chemical compositions, higher in crude protein but lower in cell wall constituents. In general, the means of *in vitro* DMD, OMD and CPD were significantly higher ($p<0.01$) in legumes compared with grasses.

Gas production and metabolizable energy contents

In vitro gas production characteristics of the forages are presented in Table 3. Gas production rapidly increased with increasing incubation time from 3 h to 48 h, and it was relatively constant from 48 hrs to 96 hrs. In general, *C. plectostachyus* and *P. purpureum* had higher gas production than the other grasses. The extent of gas production at 96 h incubation time ranged from 34.3 ml/200 mg (*A. compressus*) to 49.4 ml/200 mg (*C. plectostachyus*), potential gas production (a+b) from 37.3 ml/200 mg (*B. decumbens*) to 49.4 ml/200 mg (*C. plectostachyus*) and the rate of gas production (c) from 0.043 ml/h (*A. compressus*) to 0.127 ml/h (*C. plectostachyus*). Krishnamoorthy (1995) showed that cumulative gas production of several tropical grasses at 24 h incubation ranged from 26.1 to 49.8 ml/200 DM. Data on legume forages show the highest extent of gas production at 96 h incubation was for *L. leucocephala* followed by *P. phaseloides*, while the lowest was in *C. pubescens*. Similar results were obtained for potential and rate of gas production. Wide variation was reported in gas production for the other tropical legumes. This confirms the earlier study of Krishnamoorthy (1995) that cumulative gas production of *C. pubescens*, *G. maculata* and *L. Leucocephala* at 24 h incubation was 32.4, 38.7 and 29.3 ml/200 DM, respectively. The present study indicated that *in vitro* gas production of the forages was closely related with their digestibility. It has been shown that DMD, OMD and CPD of *C. plectostachyus* and *P. purpureum* were higher than those of other grasses. Similarly, DMD, OMD and CPD of *L. leucocephala* and *P. phaseloides* were higher compared to those of other legumes. These mean the forages contained more degradable fractions than the other forages that may have been fermented in the rumen which resulted in much higher volatile fatty acids (VFAs) and gas production. The results were also in agreement with the observation of Menke et al. (1979) that the amount of gas released when a feed is incubated *in vitro* with rumen fluid is closely related to the digestibility of the feed.

Metabolizable energy (ME) content of forage is very important to support animal production. As shown in Table 3, the ME content of grasses varied from 6.4 MJ/kg (*A. gayanus* and *A. compressus*) to 9.3 MJ/kg (*C. plectostacyhus*); while the ME content of legumes ranged from 6.5 MJ/kg (*C. pubescens*) to 8.3 MJ/kg (*L. leucocephala*). The ME content of other tropical grasses varied from 7.1 to 9.4 MJ/kg (Krishnamoorthy, 1991) and from 5.76 to 9.12 MJ/kg (Nouregia et al., 1999). While Singh (1981) and Devendra (1982) obtained that the ME content of tropical legumes varied from 6.14-8.66 MJ/kg. Menke and Steinngas (1988) suggested a strong correlation between ME value measured *in vivo* and predicted from 24 h *in vitro* gas production, crude protein and crude fat content of the forage. In the present study, the ME content was very consistent with nutrient content, digestibility and gas production of the forages. Furthermore, the OMD of the forages in this study was higher than 50%, indicating the high potential to supply metabolizable energy, as suggested by Abdulrazak et al. (2001). It can be seen that the cumulative of gas production at 24 h incubation, potential gas production (a+b) and the rate of gas production (c) was significantly higher ($p<0.05$) in legumes compared to those of grass, while no significant difference was found for ME content.

The results of this study showed that nutritive value of forages in North Sumatra during the rainy season appeared to be high as ruminant feed. In general, the forage legumes contained higher amounts of crude protein but were lower in fiber content (NDF and ADF) resulting in higher digestibility compared to grass. Among species of grasses and legumes, the best quality was noted for *Cynodon plectostachyus* and *Leucaena leucocephala*, respectively. It suggested the proper feeding of ruminants with grass and legume could improve ruminant production in North Sumatra, Indonesia.

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