

Feed Evaluation Based on Gas Production of Twelve Tropical Feedstuffs

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ABSTRACT

This study was conducted to determine the chemical composition and production of gas by fermentation in the rumen of twelve tropical feedstuffs commonly utilized which are fodder trees and shrub species, namely red flower turi (*Sesbania grandiflora* L) leaves and stems skin, white flower turi (*Sesbania grandiflora*) leaves and stems skin, leucaena (*Leucaena leucocephala*) leaves, Calliandra (*Calliandra calothyrsus*) leaves, ketapang (*Terminalia catappa* L.) leaves, walnut (*Canarium indicum* L.) leaves, teh-tehan (*Duranta repens*) leaves, tea (*Camellia sinensis*) leaves, bamboo (*Bambusa arundinacea*) leaves, and mahogany (*Swietenia mahagoni*) leaves. Measurement of gas production was performed by *in vitro* at 2, 4, 8, 18, 30, 48, 72 h of incubation. Tannin activity was measured in each sample at the time of measurement of gas production by dividing into two groups: the one with polyethylene glycol (PEG) and the other one without PEG. Result showed that the Crude protein (CP) of the samples studied ranged from 11.33 - 32.42% the lowest was found in mahogany (*Swietenia mahagoni*) leaf and highest was obtained in *sesbania grandiflora* (red flower). The content of fiber (CF) ranged from 10.31 to 32.58%. While the total tannins showed ranging from 0.22 to 12.07%, the lowest total tannin concentration was found in *sesbania grandiflora* (white flower) stems skin of 0.22% and the highest obtained at *Terminalia catappa* L is 12.07%. Measurement of gas production *in vitro* shows that in all samples, gas production increased when PEG was given. Based on tannin activities measurement in present study, the use of PEG improved rumen microbial degradation. The measurements of tannin content showed that condensed tannins were varied from 0.05% (DM) in white Turi stem to 3.34 % (DM) in Mahogany leaves.

Keywords: Evaluation, Tropical-feedstuffs, Gas-production

INTRODUCTION

Forages, typically legumes and other fodders, are rich of phenolic compounds, such as tannin (Kustantinah 2012). This substance is known to have protective effect against predators. From ruminant nutrition perspective, tannin-rich plants have both valuable and harmful effects. The beneficial effects of tannin is including: antiparasitic, antihelminthic, anticoccidia, and decreasing methanogene (Cieslak et al., 2013; Kustantinah *et al.* 2014). However, one of the negative effects of tannin is that tannin binds protein, makes some of the organic matters (protein) unavailable for ruminal degradation. Study to evaluate the availability of organic matter can be done by *in-vitro* gas production technique. The restriction in measuring fermentation through gas production method is on the presence of tannin or phenolic compound in the forage or fodders. As stated before, the bond between tannin and organic matter (protein) reduces the degradation process in the rumen, which in turn will lower gas productions. This study evaluate the use of Poly Ethylene Glycol (PEG) to

interfere the tannin-protein bond, hence increase organic matter degradation and positively effect on maximizing gas production as the result of fermentation.

MATERIALS AND METHODS

Twelve feedstuffs from 10 kinds of forages (Table 1) were used in this study, that commonly used by the local farmers to feed their goats. The forages were planted in Yogyakarta. Evaluations that have done were based on the chemical composition and fermentation gas production according to the method of Menke and Steingass (1989). Forages which evaluated were taken from edible portion of the plants. Analysis for gas production were done by *in-vitro* according to the method generated by Menke and Steingass (1988), that has been modified by Blummel and Orskov (1989). Sample used for fermentation gas production were dried at the temperature of 55°C, ground to pass screen with diameter 1 mm (Tillman *et al.*, 1998; Kustantinah, 2015).

Table 1. Twelve locally planted forages that used in this study

No	Forages samples	
	Local name	Latinness name
1	White flower Turi, leaves part	<i>Sesbania grandiflora</i>
2	White flower Turi, stem skin part	<i>Sesbania grandiflora</i>
3	Mahogany leaves	<i>Suitenia mahagony</i>
4	Calliandra leaves	<i>Calliandra calothyrsus</i>
5	Bamboo leaves	<i>Bambusa arundinaceae</i>
6	Canary leaves	<i>Canarium indicum</i> L.
7	Tea leaves	<i>Camellia sinensis</i>
8	Ketapang leaves	<i>Terminalia catappa</i> L.
9	Leucaena leaves	<i>Leucaena leucocephala</i>
10	Teh-tehan leaves	<i>Duranta repens</i>
11	Red flower Turi, leaves part	<i>Sesbania grandiflora</i>
12	Red flower Turi, stem skin part	<i>Sesbania grandiflora</i>

Gas production measurement was performed using rumen fluid as the source of microbes. The ruminal fluid was collected from cattle that fed King Grass (*Pennisetum hybrid*) and wheat pollard, with the ratio of 70:30. To identify whether the samples was contained tannin or not, each sample was divided into 2 tubes, each tube contained 200 mg DM. In the first tube, after the sample was weighed, poly ethylene glycol (PEG) was added at the same level of the sample. If the sample contains tannin, the tannin will be bound with PEG (Blummel and Orskov, 1989). The measurements of gas production were done at 2, 4, 8, 18, 30, 48, and 72 hour after fermentation. Calculation of the gas produced by fermentation were done using Neway program (Chen, 1994), based on equation $Y = a+b(1-e^{-ct})$, where Y = Volume of total gas produced in time t; a = gas production from easily degraded fraction; b = gas production from potentially degraded fraction; and c = rate of gas production of b fraction (Chen, 1994; Kustantinah, 2012). Variables observed in this study were chemical composition of the sample, gas production from easily degraded fraction (a fraction); gas production from potentially degraded fraction (b fraction); gas production from total fraction degraded and fermented (a+b fraction). Evaluation of Metabolizable Energy (ME) was done using gas production at 48 hours after fermentation (Blummel and Orskov, 1989). The data obtained were statistically analyzed using Oneway analysis of variance (ANOVA), and continued with Duncan's new Multiple Range Test (Astuti, 1980).

RESULTS AND DISCUSSION

Gas production measurement

Gas production of the easily degraded fraction, or parameter a, of forages samples with PEG treatment always higher than that of forages sample without PEG treatment. This suggests that tannin reduce the process of microbial degradation. *In vitro* study using fermentation gas production method can be done to qualitatively indicate the phenolic compound in forage samples. However, this method cannot be used to quantitatively measure the level of phenolic compound in the samples. Results showed that in all forages samples in this study (Table 2), on samples with both PEG (+) addition and without PEG (-) addition, the longer batch incubation time, the more gas production. At the end of the incubation time (h 72), gas production in all samples were not higher than 60 ml/200 mg BK. This result suggests that organic matter degradation in forages samples was not quite high, as shown by the gas production. PEG treatment influence organic matter degradation of forages samples. The increase in gas production was detected in all batches incubation time and all samples that measured (Table 2). This result were in accordance with Gameda and Hassen (2015) study that showed PEG and PVP treatments were beneficial in forages samples that contain tannin. Enhancement of gas production appeared low in white Turi and quite high (40%) in Canary (Table 2), and consistent in all batches incubation times. Kondo *et al.* (2014) reported beneficial effects of PEG treatments. The use of PEG in the forages samples increased gas production 1.7% in silage green tea by product dan 11.7% in silage black tea by product. From the increase of gas production, the effect on N-NH₃ production was also evaluated. N-NH₃ concentration were 43.3% in Green tea and 56.7% in black tea.

Total gas production of degraded fraction (ml/200 mg)

Evaluation of feed quality using estimation in gas production of total degraded fraction (a+b fraction) have shown that addition of PEG in all forages samples increased gas production ($P < 0.05$). The increased in gas production in Leguminosae leaves samples (Calliandra, Leucaena, and Canary) were higher than that of other leaves samples. Different results were showed in Bamboo leaves and red flower Turi stem skin. The increased of gas production was very low in both samples. This might showed the tannin bond by PEG in Calliandra, Leucaena, and Canary. The increase in gas production after PEG addition indicated that activities tannin can be reduced by eneration of tannin-PEG bond, hence tannin-protein bond and tannin-carbohydrate bond (especially fibre) can be broke down and ruminal microbes are able to degrade this component. Other possibility showed that the microbial activities was not disturbed by the presence of tannins and microbes in the rumen work more effective in degrading nutrients. However, it has been reported that after species of ruminal bacteria, namely streptococcus caprinus (predominant in Goats), selenomonas ruminantium, prevotella ruminicola, Butyrivibrio sp, Lacto bacillus sp and Enterobacteriaceae sp, can utilize both condensed and hydrolysable tannin as a sole source of energy (Pell et al 2001). After Brooker et al (1994) streptococcus caprinus bacteria found in the goat rumen had the ability to tolerate up to 3% of hydrolysable or condensed tannins.

The observations of the gas production from degraded fraction (a+b fraction), as well as phenolic component (total phenol, total tannins, and condensed tannins) it can be generated that there was no correlation between the height of phenolic components and the value of gas production. The increased of gas production did not have any correlation with the tannin or phenolic component content. The highest total phenol and tannin were found on the leaves of ketapang (*Terminalia catappa* L.) and the highest as well as white flower *Sesbania grandiflora*. However, the lowest gas production (a+b) was found on Canary (*Canarium indicum* L.) and on the white Turi (*Sesbania grandiflora*), and therefore there was

no consistency. Results in this study were in accordance with the results of Jayanegara and Sofyan (2008). Correlations between tannin in the forages (total phenol, total tannins, and CT) and gas production were not always linear. It might be attributed with the complex tannins structure, as well as genetic variation between forages. Barman and Ray (2008) showed that during the first 24 h of incubation there was a gradual reduction in gas production due of the increasing of tannin level (0% of tannin, gas production/24 h= 55.7±2.09 ml ; 4% of tannin, gas production/24 h= 53.50±2.29 ml. 8% of tannin, gas production/24 h= 48.17±0.60 and 12% of tannin, gas production/24 h= 42.50±3.50 ml). This observation were in agreement with findings of Kamalak *et al* (2004) that the higher total condensed tannin (TCT) content will result in lower total gas production, this is observed in the leaves of *Juniperus communis* and *carpinus betulus*, respectively showing the total gas production of 59.59 and 60.13 and the TCT content of 20.34 % And 19.78%.

Table 2. Gas production (ml/200 mg DM) forages at different batches of incubation times with and without the presence of PEG and percentage of as production due to PEG addition

Forage species and part used	Hours of incubation																				
	2		4		8		18		30		48		72								
	PEG (-)	PEG (+)	%*	PEG (-)	PEG (+)	%*	PEG (-)	PEG (+)	%*	PEG (-)	PEG (+)	%*	PEG (-)	PEG (+)							
<i>Sesbania grandiflora</i> , white flower, leaves	9.1	9.8	7.1	16.7	17.2	3.0	30.3	30.5	0.8	42.4	42.6	0.4	48.8	49.0	0.5	54.3	54.5	0.4	58.4	58.4	0
<i>Sesbania grandiflora</i> , white flower, stems skin	6.3	8.4	33.5	13.2	15.4	16.9	25.8	28.1	9.2	36.1	38.3	6.1	41.5	44.0	6.1	45.3	48.2	6.4	47.5	50.5	6.2
<i>Swieteniamahogany</i> , leaves	8.3	10.7	29.8	12.6	16.9	34.7	17.9	25.8	44.0	52..	52..	91.9	33.7	39.7	18.1	39.1	44.2	12.9	42.3	47.3	11.8
<i>Calliandra calothyrsus</i> , leaves	10.1	12.1	19.4	15.2	18.7	23.0	21.4	27.5	28.4	30.1	39.4	31.0	35.5	47.1	32.6	41.8	54.3	29.8	45.4	58.1	28.0
<i>Bambusa arundinaceae</i> , leaves	4.7	5.9	26.2	7.5	9.2	21.7	12.5	14.9	19.5	20.5	22.9	11.7	25.4	27.5	8.1	29.4	31.5	7.3	31.6	33.9	7.2
<i>Canarium indicum</i> L., leaves	6.0	8.3	39.7	9.7	13.4	37.3	14.9	19.9	44.4	22.9	29.5	42.3	27.5	35.7	40.4	31.5	40.1	36.9	33.9	43.4	34.9
<i>Camellia sinensis</i> , leaves	8.8	11.1	27.4	13.6	17.3	27.0	20.1	26.6	32.4	32.3	41.0	27.0	40.8	48.8	19.6	47.0	54.6	16.3	51.1	58.8	15.0
<i>Terminalia catappa</i> L., leaves	6.0	8.3	39.7	9.4	12.6	34.2	14.0	18.4	30.9	20.9	28.9	38.3	26.8	35.9	33.9	31.9	40.4	26.5	34.6	43.2	24.8
<i>Leucaena leucocephala</i> , leaves	8.1	10.3	26.6	13.0	16.5	27.2	18.8	25.0	33.2	25.8	35.0	35.5	31.2	41.7	33.8	35.5	46.8	31.6	38.3	50.1	30.8
<i>Duranta repens</i> , leaves	5.7	7.7	35.3	9.9	12.9	30.4	15.6	21.1	35.3	29.9	39.3	31.7	40.7	47.1	15.8	46.3	51.4	11.0	48.1	53.6	11.4
<i>Sesbania grandiflora</i> red flower, leaves	10.2	13.1	28.8	18.2	22.4	23.0	32.9	36.3	10.6	43.5	47.3	8.8	48.4	52.3	8.0	52.8	56.6	7.3	55.0	58.8	6.9
<i>Sesbania grandiflora</i> red flower, stems skin	8.6	9.8	14.4	14.6	16.8	14.6	25.4	28.2	10.2	35.8	39.0	9.0	41.3	43.7	6.0	45.7	47.8	4.5	48.0	50.0	4.2

Table 3. Gas production of a and b fractions (ml/200 mg)

No	Forage species and part used	a fraction			b fraction		
		Non PEG	PEG	Delta	Non PEG	PEG	Delta
1	<i>Sesbania grandiflora</i> , white flower, leaves	2.51	3.58	1.07±0.38 ^{bcd}	53.69	55.45	1.75±0.71 ^a
2	<i>Sesbania grandiflora</i> , white flower, stems skin	- 0.45	1.35	1.81±0.22 ^{ef}	47.23	48.77	1.54±0.46 ^a
3	<i>Swietenia mahagony</i> , leaves	3.85	4.81	0.95±0.35 ^{abcd}	42.93	48.52	5.58±2.02 ^b
4	<i>Calliandra calothyrsus</i> , leaves	7.82	8.38	0.56±0.35 ^{ab}	37.94	49.91	11.90±1.19 ^d
5	<i>Bambusa arundinaceae</i> , leaves	2.25	3.04	0.79±0.26 ^{abc}	30.16	30.90	0.73±0.08 ^a
6	<i>Canarium indicum</i> L., leaves	4.20	5.19	0.98±0.45 ^{abcd}	28.43	38.13	9.69±3.11 ^c
7	<i>Camellia sinensis</i> , leaves	4.34	5.85	1.51±0.34 ^{def}	47.31	52.58	5.27±0.92 ^b
8	<i>Terminalia catappa</i> L., leaves	4.00	4.71	0.71±0.38 ^{abc}	32.81	38.23	7.09±2.95 ^b
9	<i>Leucaena leucocephala</i> , leaves	5.02	6.28	1.25±0.52 ^{cde}	32.19	42.93	10.74±1.02 ^{cd}
10	<i>Duranta rapens</i> , leaves	0.31	0.67	0.35±0.11 ^a	49.94	53.79	3.86±0.47 ^b
11	<i>Sesbania grandiflora</i> red flower, leaves	1.99	3.98	1.99±0.19 ^f	51.87	52.86	0.98±0.38 ^a
12	<i>Sesbania grandiflora</i> red flower, stems skin	2.81	3.58	0.76±0.26 ^{abc}	44.10	45.00	0.90±0.15 ^a

^{abcd} Different superscripts in the same column indicates significantly difference (P<0.05)

Table 4. Gas production of a+b fraction (ml/200 mg)

No	Forage species and part used	Non PEG	PEG	Delta
1	<i>Sesbania grandiflora</i> , white flower, leaves	56.21	59.04	2.82±0.39 ^{ab}
2	<i>Sesbania grandiflora</i> , white flower, stems skin	46.77	50.13	3.35±0.56 ^{ab}
3	<i>Swietenia mahagony</i> , leaves	46.79	53.33	6.54±2.52 ^{cd}
4	<i>Calliandra calothyrsus</i> , leaves	45.76	58.29	12.53±0.96 ^e
5	<i>Bambusa arundinaceae</i> , leaves	32.41	33.94	1.52±0.20
6	<i>Canarium indicum</i> L., leaves	32.63	43.31	10.68±3.48 ^e
7	<i>Camellia sinensis</i> , leaves	51.64	58.44	6.79±0.66 ^d
8	<i>Terminalia catappa</i> L., leaves	36.82	42.94	6.12±0.37 ^{cd}
9	<i>Leucaena leucocephala</i> , leaves	37.22	49.21	11.99±1.49 ^e
10	<i>Duranta rapens</i> , leaves	50.25	54.46	4.21±0.52 ^{bc}
11	<i>Sesbania grandiflora</i> red flower, leaves	53.86	56.86	2.97±0.22 ^{ab}
12	<i>Sesbania grandiflora</i> red flower, stems skin	46.91	48.57	1.66±0.33 ^a

^{abcd} Different superscripts on the same column indicates significantly difference (P<0.05)

CONCLUSION

Poly Ethylene Glycos (PEG) was useful to reduce tannins or CT activities as shown in the height of gas production in PEG treatment. The concentration of total phenol, tannins, and CT contents do not always correlated with the gas production.

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