Rumen degradation properties of tropical legumes feed under in sacco studies

S F I Rahmat¹, I G Permana² and Despal³

¹ Department of Nutrition and Feed Technology, IPB University, Bogor, 16680, sarifilzaizzatirahmat@apps.ipb.ac.id
² Department of Nutrition and Feed Technology, IPB University, Bogor, 16680, permana@apps.ipb.ac.id
³ Department of Nutrition and Feed Technology, IPB University, Bogor, 16680, despal@apps.ipb.ac.id

Corresponding author e-mail: permana@apps.ipb.ac.id

Abstract. Degradation properties of protein feed sources such as tropical legumes is very important to match with microbial protein synthesis and by pass protein requirements in dairy cattle ration formulation. However, the information is still limited. This study aims to determine the degradability of dry matter (DMD) and organic matter (OMD) from several legumes in Indonesia using in sacco method. There are 11 types of tropical legumes that are commonly used in dairy cattle ration have been studied, namely acacia, alfalfa, pterocarpus, gliricidia, indigofera, calliandra, butterfly leaf, leucaena, albizia, tamarind, and sesbania. The dried forage mesh samples were put into nylon bags and incubated in the rumen of two fistulated Friesian Holstein bulls for 0, 3, 6, 9, 12, 15, 24, 48, and 72 hours. Parameter observed were degradability of dry matter (DMD), and organic matter (OMD), kinetic parameters, and effective degradation. The data were analysed using descriptive statistic and regression from SAS University software. The result that sesbania and indigofera grouped into highly degradable forage (degradability > 80%), while acacia, albizia, calliandra grouped into low degradable forage (degradability < 50%). From this study it can be concluded that each type of legume has different degradability characteristics using in sacco method.

Keywords: legume, dry matter degradation, organic matter degradation, in sacco, dairy cattle.

1. Introduction

Dairy cattle need regular supply of feedstuffs that could meet basic requirement, sustain pregnancy, and milk production. Therefore, it is necessary to find economical feedstuffs such as legumes. Legume is a plant in the form of forage which is rich in protein sources and could be used as animal feed. Legumes are dicotyledons and have the ability to fix nitrogen directly from the air because of their symbiotic reaction with certain root and stem bacteria [1]. Legumes establish a symbiotic association with certain root nodule-forming soil bacteria such as Rhizobium spp., which are capable of fixing N₂ [2]. Furthermore, they belong to the phylum Spermatophyta and have 3 sub families, namely faboideae or papilionoideae, caesalpinioideae, and mimosoideae or mimoseae [1]. In addition, legumes as sources of reserve feed for use in drought or prolonged dry season conditions [3]. However, it is not widely used as a feed ingredient by farmers in Indonesia, even though it could reduce the use of concentrates in rations which are quite expensive.
The value of forages or legumes as supplements in feed dependent on their capacity to provide essential nutrients to the rumen microbial population and to meet the host animal's requirements thus increasing the efficiency of feed utilization [4]. Although laboratory analyses provide information regarding the nutritive value of the legumes, it is necessary to screen legumes in terms of additional information regarding the degradation characteristics in the rumen. The method that has been developed to estimate the degradability of dairy feed ingredients is the in sacco method [5]. The in sacco method reflects the degradability and supply of substrate for biomass [6]. In general, this method has the advantage of being able to determine the rate of degradation of feed ingredients in the digestive organs at a certain time, simulate the rumen environment [7]. Evaluation of the degradation of feed ingredients in sacco could determine the value of the easily and potentially degraded feed fraction, including the rate of degradation to calculate the value of theoretical degradation [8].

There is a lack of information on the amount of nutrients in legumes for dairy cattle feed, and this hinders the determination of the rate of degradation of the feed. Therefore, the purpose of this study is to determine the degradation of dry matter (DMD) and organic matter (OMD) in several types of tropical legume in Indonesia using the in sacco method.

2. Material and methods

2.1. Analysis of the nutrient content of some tropical legumes

This study was carried out from September 2020 to November 2021 at the Dairy Animal Nutrition Laboratory, Faculty of Animal Husbandry, Bogor Agricultural University. It was conducted on the 11 types of legumes that are commonly used in dairy cattle rations in Indonesia, namely acacia (Acacia mangium), alfalfa (Medicago sativa), pterocarpus (Pterocarpus indicus), gliricidia (Gliricidia sepium), indigofera (Indigofera zollingeriana), calliandra (Calliandra calothyrsus), butterfly leaf (Bauhinia purpurea), leucaena (Leucaena leucocephala), albizia (Albizia chinensis), tamarind (Tamarindus indica), and sesbania (Sesbania grandiflora). Samples were taken from the leaves and stems, which are the parts commonly eaten by the cattle. Furthermore, the samples were then chopped, dried at room temperature for 2 days, and dried in an oven at 60°C for 48 hours. Then dried forage sample [9] were weighed and ground to pass through a 2.0 mm sieve. The nutritional content of legumes such as dry matter, ash, crude protein, crude fat, crude fiber, and BETN was analyzed using near-infrared spectroscopy (NIRs). It was carried out by adding 50 g of the sample into a petri dish and placing it on a rotating medium. The sample was then irradiated in triples with infrared light of 1000 - 2500 nm wavelength to reduce bias. The irradiation process produced a reflectance spectrum which was then calibrated data for dry forage ruminants in order to produce the proximate data.

2.2. Analysis of the degradability characteristics of tropical legumes using in sacco method

The in sacco method was used to determine the degradation of dry matter (DMD), and organic matter (OMD) in feed. Moreover, this study used two Friesian Holstein bulls with rumen fistulas that had an average body weight of ± 510 kg. The cattle were fed twice a day every 07.00 and 15.00 WIB with 60% napier grass and 40% concentrate mixture based on DM. Each ± 5 g dried legume sample was then put into an ANKOM of nylon bag of dimensions 10 x 15 cm with a porosity of ± 50 microns). Samples were incubated in the rumen with incubation of 3, 6, 9, 12, 15, 24, 48, and 72 hours. Some samples were incubated in the rumen for 3, 6, 9, 12, 15, 24, 48, and 72 hours, respectively, while the samples that were not incubated (0 hours) were rinsed only with running water. Moreover, the incubated samples were inserted into the rumen fistula before feeding time in the morning. At the end of the incubation period, the samples were removed from the rumen fistula and rinsed with running water until clear. Furthermore, they were dried in an oven at 60°C for 4 days, weighed, and then analyzed to determine the degradation of dry matter (DMD) and organic matter (OMD). Finally, the kinetic parameters of DMD and OMD were analyzed using the exponential equation by Orskov and Mc Donald, 1979 [7] as follows (Equation 1):
where \( y \) is the percentage of degraded DMD or OMD in the rumen at time \( t \), \( a \) is the dissolved fraction in \%, \( b \) is the insoluble potentially degraded fraction in \%, \( c \) is the constant value of the degradation rate of fraction \( b \) (\%/hour), and \( t \) is the time of degradation. The potential for degradation (PD) was determined by equation (2):

\[
PD = a + b
\]

Furthermore, the effective degradation (ED) of DMD or OMD was calculated using the formula by ARC, 1980 [8] (Equation 3) while assuming a rumen outflow rate of 6%/hr.

\[
ED = a + \frac{bc}{(k+c)}
\]

where \( a \), \( b \), and \( c \) are the same as in Equation 1 and \( k \) is the rumen outflow rate. Finally the DMD and OMD values were correlated between the respective nutritional content of the legume.

2.3. Experimental design
This study was carried out on 11 types of legumes commonly used in dairy cattle rations in Indonesia with sample incubation periods of 3, 6, 9, 12, 15, 24, and 72 hours, respectively. Moreover, it used the in sacco method and each sample was introduced twice into the rumen fistula of the dairy cattle. Finally, the initial samples and rumen incubation results were analyzed proximately as a database for DMD and OMD.

2.4. Data analysis
The data obtained were analyzed by descriptive statistics and non-linear regression. Moreover, the descriptive statistical analysis was used to classify feed based on its degradability, while the non-linear regression analysis was used to determine the fermentation kinetics of the feed.

3. Results and discussion

3.1. Nutrient content of some tropical legume
The nutrient content of some tropical legumes is presented in Table 1. Based on the data, the nutritional content of the legumes varies. The average of chemical composition of the legumes were dry matter 92.71% ± 0.99 (dry state); organic matter 92.57% ± 1.90; crude protein 19.88 ± 4.45, crude fat 2.29 ± 0.42, crude fiber 17.63 ± 5.20, and NFE 45.48 ± 6.67. In Table 1 showed that, tamarind had the highest dry matter content and the lowest crude protein, while indigofera had the lowest dry matter content and the highest crude protein. Albizia had the highest organic matter content and the lowest ash content, while alfalfa had the lowest organic matter content and the highest ash content. Additionally, butterfly leaf had the highest crude fat content and calliandra had the lowest crude fat content. Alfalfa had the highest crude fiber content, and sesbania had the lowest crude fiber content. Tamarind had the highest NFE content and butterfly leaf had the lowest NFE content.

| Legumes                  | Nutrient content (%) | Moisture | DM     | OM     | Ash    | CP     | CL     | CF     | NFE    |
|--------------------------|----------------------|----------|--------|--------|--------|--------|--------|--------|--------|
| Acacia (Acacia mangium)  | 75.11                | 24.89    | 95.32  | 4.68   | 16.63  | 1.93   | 19.04  | 50.04  |
| Alfalfa (Medicago sativa)| 73.78                | 26.22    | 90.47  | 9.53   | 14.47  | 2.79   | 28.40  | 38.18  |
| Pterocarpus (Pterocarpus indicus)| 70.61| 29.39    | 94.00  | 6.00   | 21.63  | 1.98   | 21.51  | 42.34  |
| Gliciridia (Gliciridia sepium)| 68.14| 19.86    | 90.54  | 9.46   | 25.18  | 2.25   | 14.15  | 41.34  |
| Indigofera (Indigofera zollingeriana)| 75.84| 24.16    | 90.68  | 9.32   | 26.18  | 2.37   | 12.52  | 40.23  |
| Calliandra (Calliandra calothyrsus)| 68.59| 31.41    | 94.22  | 5.78   | 21.39  | 1.55   | 15.84  | 48.41  |
| Butterfly leaf (Bauhinia purpurea)| 62.96| 37.04    | 91.06  | 8.94   | 21.71  | 3.02   | 23.07  | 35.76  |
| Leucaena (Leucaena leucocephala)| 71.44| 28.56    | 92.08  | 7.92   | 22.68  | 2.46   | 16.33  | 43.26  |
| Albizia (Albizia chinensis)| 65.45                | 34.55    | 95.39  | 4.61   | 17.56  | 2.31   | 14.02  | 54.64  |
| Tamarind (Tamarindus indica)| 60.80                | 39.21    | 92.88  | 7.12   | 11.60  | 1.99   | 18.51  | 55.30  |
| Sesbania (Sesbania grandiflora)| 76.60                | 23.40    | 91.61  | 8.39   | 19.69  | 2.54   | 10.50  | 50.82  |

DM=dry matter; OM=organic matter; CP=crude protein; CL=crude lipid; CF=crude fiber; NFE=nitrogen free-extract.
3.2. Dry Matter Degradability (DMD) of some tropical legumes
The DMD of some legumes at incubation periods of 0, 3, 6, 9, 12, 15, 24, 48, and 72 hours, respectively, in the rumen using in sacco method is presented in Table 2. Moreover the table showed it increased with the period of incubation. The DMD of some legumes were significantly different due to the influence of the feed, incubation time, and interaction of feed with incubation time (P < 0.01). Sesbania and indigofera had the highest DMD while acacia, sengon, and calliandra had the lowest values. Moreover, each feed ingredient had degradation variations and was highly dependent on the part of the plant, age, and level of lignification [12].

| Legumes            | Degradation time (%/h) |
|--------------------|------------------------|
|                    | 0         | 3         | 6         | 9         | 12        | 15        | 24        | 48        | 72        |
| Acacia (*Acacia mangium*) | 4.47     | 28.4     | 29.89    | 31.97    | 30.84    | 32.47    | 37.47    | 38.77    | 43.04    |
| Alfalfa (*Medicago sativa*) | 14.01    | 39.52    | 41.93    | 45.96    | 53.79    | 60.00    | 65.43    | 67.82    | 68.55    |
| Pterocarpus (*Pterocarpus indicus*) | 10.35    | 26.84    | 35.15    | 33.43    | 37.08    | 43.41    | 48.41    | 56.30    | 58.91    |
| Gliciridia (*Gliciridia sepium*) | 18.21    | 46.12    | 46.39    | 55.96    | 60.9     | 64.19    | 73.18    | 76.32    | 77.55    |
| Indigofera (*Indigofera zollingeriana*) | 18.98    | 46.54    | 52.61    | 55.96    | 61.1     | 69.20    | 74.96    | 80.82    | 82.97    |
| Calliandra (*Calliandra calothyrsus*) | 9.02     | 24.50    | 24.55    | 27.35    | 28.09    | 28.77    | 32.61    | 38.90    | 45.56    |
| Butterfly leaf (*Bauhinia purpurea*) | 13.1     | 30.25    | 39.71    | 45.96    | 52.18    | 54.81    | 60.58    | 64.79    | 66.06    |
| Leucaena (*Leucaena leucocephala*) | 8.93     | 36.26    | 40.13    | 42.79    | 44.08    | 51.10    | 52.70    | 65.45    | 70.47    |
| Albizia (*Albizia chinensis*) | 10.28    | 27.94    | 27.92    | 29.51    | 29.34    | 30.63    | 32.15    | 35.56    | 37.61    |
| Tamarind (*Tamarindus indica*) | 16.63    | 38.03    | 39.45    | 41.98    | 40.51    | 45.23    | 47.98    | 54.36    | 59.06    |
| Sesbania (*Sesbania grandiflora*) | 26.48    | 48.12    | 60.20    | 62.94    | 68.09    | 71.90    | 75.01    | 81.94    | 85.31    |

P-value: Feed (P < 0.0001); Time (P < 0.0001); Feed x Time (P < 0.0001).

Figure 1. shows the estimated degradation of the DMD of some legumes in the rumen. It could be seen that at certain periods, 50-60% of the DMD of some legumes had been degraded in the rumen. They include sesbania, indigofera at 6 hours, gliciridia at 9 hours, alfalfa and butterfly leaves at 12 hours, lamtoro at 15 hours, and pterocarpus, tamarind at 48 hours. However, calliandra, acacia, and albizia had not reached 50% - 60% degradation at 72 hours. Finally, sesbania had the highest DMD because it had the lowest crude fiber content.

![Figure 1. Estimated degradation of DMD of some tropical legumes.](image-url)
The results of the kinetic parameter equation and ED of DMD are presented in Table 3. It indicated that coefficients \(a\), \(b\), \(a + b\), and ED of DMD varied between legumes. The results also showed that the Kinetic parameters had a significant effect (\(P < 0.05\)) on \(a\), \(b\), and \(a + b\), \(c\) had no significant effect (\(P > 0.05\)), and ED had a significant effect (\(P < 0.01\)). Additionally, the highest \(a\) value was sesbania, while acacia had the lowest value, meaning that sesbania was rapidly degraded in the rumen and acacia was slowly degraded. The value of \(b\) was highest in indigofera, while tamarind, acacia, calliandra, and albizia had the lowest value, meaning that the insoluble fraction of indigofera had the most potential to be degraded in the rumen compared to other legumes. Sesbania and indigofera had the highest \(a + b\) values while acacia and albizia had the lowest values, meaning that the amount of dissolved material degraded in the rumen compared to other legumes. Sesbania and indigofera had the highest \(a + b\) values while acacia and albizia had the lowest values, meaning that the amount of dissolved material and the potential for degraded materials in sesbania and indigofera were the highest. The results also showed that the effective degradation (ED) of DMD was highest in sesbania and indigofera, followed by gliricidia, alfalfa, butterfly leaf, leucaena, tamarind, pterocarpus, and acacia, albizia calliandra had the lowest value. Some legumes have an anti-nutrition, namely tannin. Highest condensed tannin contents were recorded in Calliandra calothyrsus (11.07%) while sesbahia did not contain condensed tannins [3]. The presence of tannin content in legumes can inhibit the degradation of feed ingredients [13].

### Table 3. Kinetic parameters and effective degradation of DMD.

| Legumes                     | Kinetic parameters (%) | Kinetic parameters | ED |
|------------------------------|------------------------|-------------------|-----|
| Acacia (Acacia mangium)      | \(6.25^a\)             | 30.88\(^c\)       | 0.29| 37.13\(^f\)| 31.37\(^e\) |
| Alfalfa (Medicago sativa)    | \(17.23^b\)            | 50.37\(^b\)       | 0.12| 67.60\(^e\) | 50.60\(^a\) |
| Pterocarpus (Pterocarpus indicus) | \(15.75^bc\)           | 43.94\(^b\)       | 0.06| 59.68\(^d\) | 36.91\(^bc\) |
| Gliricidia (Gliricidia sepium) | \(22.26^b\)          | 54.37\(^ab\)      | 0.11| 76.63\(^b\) | 57.45\(^ab\) |
| Indigofera (Indigofera zollingeriana) | \(21.04^b\)       | 61.99\(^a\)       | 0.13| 83.03\(^a\) | 63.41\(^a\) |
| Calliandra (Calliandra calothyrsus) | \(15.37^bc\)         | 27.91\(^c\)       | 0.05| 43.28\(^e\) | 28.20\(^c\) |
| Butterfly leaf (Bauhinia purpurea) | \(14.26^bc\)     | 50.99\(^ab\)      | 0.11| 65.25\(^c\) | 47.30\(^c\) |
| Leucaena (Leucaena leucocephala) | \(17.15^b\)        | 51.27\(^b\)       | 0.07| 68.42\(^c\) | 44.97\(^cd\) |
| Albizia (Albizia chinensis)   | \(12.44^bc\)           | 22.22\(^c\)       | 0.39| 34.65\(^f\) | 29.39\(^e\) |
| Tamarind (Tamarindus indica)  | \(21.95^ab\)           | 32.94\(^c\)       | 0.10| 54.89\(^d\) | 42.36\(^cd\) |
| Sesbania (Sesbania grandiflora) | \(29.69^a\)          | 55.00\(^ab\)      | 0.12| 84.69\(^a\) | 64.05\(^e\) |

\(a = \)soluble fraction; \(b = \)potentially degradable fraction; \(a + b = \)summary of \(a\) and \(b\) values; \(c = \)rate of degradation; ED=effective degradation.

P-value= \(a\) (\(P < 0.0128\)); \(b\) (\(P < 0.0001\)); \(c\) (\(P < 0.3948\)); \(a + b\) (\(P < 0.0001\)); ED (\(P < 0.0001\)).

### 3.3. Organic matter degradability (OMD) of some tropical legumes

Organic matter degradation (OMD) at incubation time 0, 3, 6, 9, 12, 15, 24, 48, and 72 h in the rumen is presented in Table 4. OMD of some legumes increased with increasing DMD, while in several legumes it was significantly influenced by feed, incubation time, and feed interaction feed interaction with time (\(P < 0.01\)). Sesbania and indigofera had the highest OMD while acacia, albizia, and calliandra had the lowest OMD. Many factors affect the degradability of forage nutrient content in the rumen, namely stage of maturity, forage species, and preservation method [14].

### Table 4. Degradation of organic matter at incubation into rumen.

| Legumes                     | Degradation time (%/h) |
|------------------------------|------------------------|
|                             | 0  | 3  | 6  | 9  | 12 | 15 | 24 | 48 | 72 |
| Acacia (Acacia mangium)      | 3.59 | 26.6 | 28.21 | 30.12 | 29.1 | 30.63 | 35.89 | 37.37 | 41.79 |
| Alfalfa (Medicago sativa)    | 11.12 | 35.7 | 37.95 | 42.31 | 50.71 | 56.91 | 62.76 | 65.37 | 65.11 |
| Pterocarpus (Pterocarpus indicus) | 9.59 | 25.42 | 33.74 | 31.88 | 35.65 | 37.74 | 42.08 | 55.23 | 57.91 |
| Gliricidia (Gliricidia sepium) | 15.33 | 43.36 | 43.65 | 53.62 | 58.74 | 62.18 | 71.74 | 75.00 | 76.35 |
| Indigofera (Indigofera zollingeriana) | 17.83 | 44.2 | 50.17 | 58.94 | 67.36 | 73.48 | 79.71 | 81.99 | 82.44 |
| Calliandra (Calliandra calothyrsus) | 8.12 | 23.87 | 23.43 | 26.36 | 26.90 | 27.74 | 31.72 | 37.82 | 45.00 |
Butterfly leaf (*Bauhinia purpurea*)

|          | 12.93 | 28.23 | 38.24 | 44.39 | 50.72 | 53.35 | 59.27 | 63.57 | 64.95 |

Leucaena (*Leucaena leucocephala*)

|          | 7.34  | 39.75 | 36.94 | 39.54 | 40.98 | 48.47 | 50.06 | 63.62 | 68.94 |

Albizia (*Albizia chinensis*)

|          | 9.5   | 26.98 | 26.8  | 28.39 | 28.11 | 29.48 | 31.16 | 34.68 | 36.8  |

Tamarind (*Tamarindus indica*)

|          | 15.84 | 36.89 | 38.26 | 40.59 | 39.22 | 44.02 | 46.96 | 53.41 | 58.46 |

Sesbania (*Sesbania grandiflora*)

|          | 25.48 | 46.26 | 58.51 | 61.37 | 67.05 | 73.74 | 81.06 | 84.55 |

P-value= Feed (P < 0.0001); Time (P < 0.0001); Feed x Time (P < 0.0001).

Figure 2 shows the estimated OMD degradation of some tropical legumes in the rumen. Furthermore, in line with the estimation from DMD after 72 hours of incubation it was seen that sesbania and indigofera could be grouped into legumes that were highly degraded (feed degradability > 80%), while calliandra, acacia, and albizia could be grouped into legumes that were difficult to degrade (feed degradability < 50%). Meanwhile, sesbania has the lowest crude fiber content, making it easier for rumen microbes to degrade organic components. The factors affecting *in sacco* nutrient degradation are sample type, sample grinding, proportion of sample weight to bag surface area, bag characteristics, bag pore size, washing procedure and animal related variations (species, breed, stage of growth or production [7a]).

The results of the kinetic parameters and effective degradation of OMD are presented in Table 5. It showed that the coefficients *a*, *b*, *a + b*, and ED of OMD varied between legumes. Moreover, the kinetic parameter equation had a significant effect (P < 0.01) on *a*, *b*, and *a + b*, while *c* had no significant effect (P > 0.05). Sesbania had the highest *a* value while acacia has the lowest value, indicating that sesbania had a soluble fraction that degraded rapidly while acacia degraded the slowest in the rumen. Indigofera had the highest *b* value and albizia, the lowest value, meaning that indigofera has an insoluble fraction that has the potential to be degraded in the rumen compared to albizia. Furthermore, the *a + b* value of OMD was in line with DMD, that sesbania and indigofera had the highest amount of dissolved material and the lowest potential for degraded feed, compared to acacia and albizia the lowest. In line with the effective degradation (ED) of DMD, the highest DE of OMD were sesbania and indigofera, followed by gliricidia, alfalfa, butterfly leaf, leucaena, tamarind, pterocarpus, and acacia, albasia, calliandra, which had the lowest values. Meanwhile, legumes contained more lignin than grasses [14]. Lignin that binds the fiber fraction in legumes will become lignocellulosic [5] so that it inhibits rumen microbial degradation and is difficult to digest [15].
Table 5. Kinetic parameters and effective degradation of OMD.

| Legumes                      | Kinetic parameters (%) | ED  |
|------------------------------|------------------------|-----|
|                             | a          | b          | c  | a + b    |
| Acacia (Acacia mangium)      | 5.87d      | 30.21de    | 0.25| 36.09e   | 29.68e  |
| Alfalfa (Medicago sativa)    | 14.11bc    | 51.25bc    | 0.11| 65.36c   | 47.34bc |
| Pterocarpus (Pterocarpus indicus) | 14.85bc | 44.24c     | 0.06| 59.09d   | 35.62de |
| Gliricidia (Gliricidia sepium) | 19.41bc | 56.09ab    | 0.11| 75.49b   | 55.30ab |
| Indigofera (Indigofera zollingeriana) | 19.77bc | 62.62a     | 0.12| 82.38a   | 61.74a  |
| Calliandra (Calliandra calothyrsus) | 14.74bc | 28.26ab    | 0.05| 43.00c   | 27.14c  |
| Butterfly leaf (Bauhinia purpurea) | 13.69bcd | 50.57bc    | 0.11| 64.26c   | 45.92bc |
| Leucaena (Leucaena leucocephala) | 17.82bc | 50.12bc    | 0.06| 67.94c   | 43.05cd |
| Albizia (Albizia chinensis)   | 11.75cd   | 22.05e     | 0.38| 33.80f   | 28.36e  |
| Tamarind (Tamarindus indica)  | 21.47abcd  | 33.04d     | 0.09| 54.51d   | 41.23abcd|
| Sesbania (Sesbania grandiflora) | 28.48ab   | 55.90ab    | 0.11| 84.37a   | 62.75a  |

* a= soluble fraction; b= potentially degradable fraction; a+b= summary of a and b values; c= rate of degradation; ED= effective degradation.

P-value = a (P < 0.0049); b (P < 0.0001); c (P < 0.4462); a+b (P < 0.0001); ED (P < 0.0001).

4. Conclusion

It was concluded that each legume had varying degradation properties in the rumen, and sesbania and indigofera had the highest potential for degradability compared to other legumes, as indicated by the degradability of dry matter (DM) and organic matter (OMD), using the in sacco method.

References

[1] Tillman A D, Hartadi H, Prewirokusumo S, Reksohadiprodjo S and Lebdosoekojo S 1998 *Ilmu makanan ternak dasar* (Yogyakarta: UGM-Press)

[2] Todd C D, Tipton P A, Blevins D G, Piedras P, Pineda M and Polacco J C 2005 Update on ureide degradation in legumes *J. Exp. Bot.* 57 (1) 5–12

[3] Ahn J H, Robertson B M, Elliott R, Gutteridge R C and Ford C W 1989 Quality assessment of tropical browse legumes: Tannin content and protein degradation *J. Anim. Feed Sci. Technol.* 27 (1–2) 147–156

[4] Elliott R and McMeniman N P 1987 *Supplement of ruminant diets with forage* In: J.B. Hacker and J.H. Ternouth (Editors) The Nutrition of Herbivores (Sydney: Academic-Press)

[5] Schwab C G, Tylutki T P, Ordway R S, Sheafer C and Stern MD 2003 Characterization of proteins in feeds. *J. Dairy Sci.* 86 (1) 86–103

[6] Blümmel M and Bullerdieck P 1997 The need to complement gas production measurements with residue determinations from in sacco degradabilities to improve the prediction of voluntary intake of hays. *J. Anim. Sci.* 64 71–75

[7] Nocek J E 1988 In situ and other methods to estimate ruminal protein and energy digestibility: A Review. *J Dairy Sci.* 71 (8) 2051–69

[8] Harfiah 2005 Penentuan nilai index beberapa pakan hijauan ternak domba *J. Aplikasi Sains Teknol.* 5 (3) 114-121

[9] AOAC 2005 *Official Methods of Analysis* 18th Ed (Gaithersburg, USA-AOAC International)

[10] Ørskov E R and McDonald I 1979 The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage *J. Agric. Sci. Camb.* 92 499–503

[11] ARC (Agricultural Research Council) 1980 *The nutrient requirements of ruminant livestock* Commonwealth Agricultural Bureaux (Surrey-Unwin Brothers the Greenham Press)

[12] Falahatizow J, Mesgaran D M, Valiki A, Tahmasbi A and Nazari M 2015 The estimation of ruminal protein degradation parameters of various feeds using in vitro modified gas production technique *Iran. J. Vet. Res.* 16 (1) 47–52
Acknowledgments
This research was funded by the Indonesian Directorate of Research and Community Service, and the national Research and Innovation Agency /BRIN within the scheme of university competitive basic research 2021 with contract No. 1/E1/KP.PTNBH/2021.