

Degradation characteristics of four different diets in the rumen of goat

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Abstract

The main aim of this experiment *in sacco* was to examine the characteristic degradation of four grasses in the rumen of goat. Those of four grasses studied were R1 = Elephant grass, R2 = Mini elephant grass, R3 = *Panicum maximum* grass, and R4 = *Brachiaria decumbens* grass. Randomised complete design (RCD) was employed to allocate four fistulated goat. The protocol for this study was approved by the Ethical Review Committee of the University of Hasanuddin Makassar, before the commencement of the experiment. Goat was kept in an individual metabolism crate and fed with general purpose diets. A general purpose (GP) diet was mixed with equal amounts of those 4 grasses Elephant grass (R1), Mini elephant grass (R2), *Panicum maximum* grass (R3) and *Brachiaria decumbens* grass (R4). The GP diet was added with 20% of rice bran. Water and salt were provided *ad libitum*. Voluntary feed intake was then measured every day by weighing feed offered at 7am and feed residue at 7 am in the next day. In order to determine the DM degradability, 3 g samples of four grasses were weighed in duplicates into standard nylon bags. The bags were incubated in the rumen and withdrawn after 4, 8, 12, 24, 48, and 72h. The result of this experiment showed that the average of feed voluntary feed intakes was dry matter 460.5g/d, organic matter 984.9g/d, and crude protein 139.8g/d, respectively. The dry matter loss at 72h after incubation was R1 = 55.7%, R2 = 55.6%, R3 = 53.2%, and R4 = 46.1%, respectively. The crude protein loss after 72h of incubation was 71.9%, 62.7%, 72.1%, and 62.5%, respectively. The characteristics degradation of R1 was a = 9.9%, b = 64.4%, and c = 0.05; R2 was a = 16.5%. b = 45.3%. c = 0.04; R3 was a = 7.4%. b = 68.2%. and c = 0.04; and R4 was a = 6.7%, b = 56.2%, and c = 0.06. Mini elephant grass had the longest of lag time (4.2h) compared to that of other grass studied (average 1.2h). It is concluded that all grasses investigated were acceptable, palatable, and readily degradable by rumen microbes in the rumen of goat. Therefore those of 4 grasses are a good feed resources for ruminant.

Introduction

In Indonesia forages such as Elephant grass, Mini elephant grass, *Panicum maximum* grass, and *Brachiaria decumbens* grass are commonly use as feed resources for ruminant. Proximate analysis of four grasses from previous researcher showed that all four grasses contain a good nutrient for ruminant. Nutrient content of Elephant grass was dry matter (DM) 19.9%, crude protein (CP) 10.12%, ether extract (EE)

1.6%, crude fibre (CF) 34.2%, ash 11.7%, and nitrogen-free extract (NFE) 42.3% (Okaraonye and Ikewuchi, 2009). Nutrient content of Mini elephant grass was DM 16.59%, CP 12.72%, CF 32.35%, and EE 2.28% (Srilidya *et al.*, 2018). *Panicum maximum* grass contains DM 21% and CP 13% (Rahalus *et al.*, 2014), whereas *Brachiaria decumbens* grass contains DM 27.5%, CP 9.84%, EE 2.36%, and CF 28.9% (Dairy Feed Online, 2021). However, their nutritive values such as voluntary feed intake, apparent digestibility, and rumen degradability of the grasses are lacking especially the rate degradability of the grasses in the rumen of ruminant. Therefore, in this study an *in sacco* experiment was conducted to examine rumen degradation characteristics of those 4 grasses in the rumen of goat. The characteristics degradation measured were a = the soluble fraction, b = potential degradation fraction, c = the rate of degradation, a +

b = the peak of degradation, and lag phase = the length adaption of rumen microbes to start degrade the feed incubated. By using a Neway method (Chen, 1995) the rate of the feed degradability in the rumen as well as the degradation curve of each grass studied could be analyzed and discussed.

Materials And Methods

This experiment *in sacco* was conducted on September to November 2021 in the field laboratory of Laboratorium Ruminant Nutrition at Faculty of Hasanuddin University. Four grasses known as R1 = Elephant grass, R2 = Mini elephant grass, R3 = *Panicum maximum* grass, and R4 = *Brachiaria decumbens* grass were investigated their characteristics degradation in the rumen of goat. The protocol for this study was approved by the Ethical Review Committee of the University of Hasanuddin University (Approved Number: 645/UN4.6.4.5.31/PP36/ 2021, Protocol UH21090601), before the commencement of the experiment.

The *in sacco* DM degradability was determined using four rumen fistulated rams with an average weight of 14kg, fitted with permanent rumen cannulae (5cm diameter, 4cm aperture and 5cm aperture lead). The rams were fistulated following sedation with 2% xylazine hydrochloride (Xylaz® Kepro Vet. Holland) at the rate of 0.3 mg/kg followed by administration of inverted L-block at the right flank area with 2% lignocaine hydrochloride (Liga ADR® SAI Parenterall). Following fistulation, intramuscular injection of 5% tramadol (Tramal® Ciron Drugs and Pharmaceuticals Ltd.) at 3 mg/kg was administered for 3 days to provide post operation analgesia. In addition, penicillin/streptomycin (Penstrep 20/25, Kepro Vet Holland) injection was administered intramuscularly for 5 days.

All fistulated goat are kept in an individual metabolism crates and fed with GP (general purpose) diet. The GP diet contains mixed of equal amount of four grasses then added with about 20% of rice bran of the diet. Water and salts are freely available and offered *ad libitum*. The GP diet was offered twice a day at about 7 am and 5 pm every day.

In order to determine the DM degradability, 3g samples were weighed in duplicates into nylon bags (50×180mm, 41µm pore size, Polyester China). The bags were hung with slits made on a flexible tube and tied using rubber bands before being suspended in the rumen of sheep via the canula. The bags were incubated in the rumen and withdrawn after 6, 12, 24, 48, 72 and 96 h. After the removal, the bags were kept inside ice cubes to stop fermentation and then rinsed under running tap water until the water became clear and free of all particles.

To determine the washing loss at 0 h, the bags were soaked in warm water at 39°C for 30min in a water bath, washed and dried for 48h at 60°C. The degradability constants were determined using the exponential equation as described by Ørskov and McDonald (1979), using a Neway Excell programme (Chen, 1995). The degradation characteristics of the feeds were defined as a = washing loss (readily soluble fraction); b representing the insoluble but fermentable fraction; c = the rate of degradation of b, and the lag phase (Ørskov and Ryle 1990).

Potential degradation (PD) was estimated as (a + b), while effective degradability (ED) of DM was calculated according to Dhanoa (1988) at rumen outflow rate (k) of 0.05 per hour. Analysis of variance and regression analysis of rumen degradation curves between one and another grass studied were analyze using software SPSS Version 24.0 (Gaspersz, 1991).

Results And Discussion

In order to measure the nutrient content of four grasses studied a proximate analysis (AOAC, 1995) was conducted and the results of the proximate analysis can be seen in Table 1.

Table 1
Nutrient content of feedstuffs studied

Nutrient	Elephant grass	Mini elephant grass	<i>Panicum maximum</i> grass	<i>Brachiaria decumbens</i> grass	Rice bran
Dry matter (%)	28.02	26.29	23.63	33.04	90.30
Organic matter (%)	82.23	82.82	88.41	90.81	85.32
Crude protein (%)	14.79	12.13	11.19	15.31	7.71
Crude fiber (%)	31.84	27.44	33.42	31.02	32.19
Crude fat (%)	3.95	6.00	5.75	4.65	3.03
Ash (%)	16.77	17.18	11.59	9.19	15.68
NFE (%)	32.65	37.25	33.50	39.83	31.68
NDF (%)	66.22	62.71	68.14	68.24	49.65
ADF (%)	41.23	36.90	42.24	39.70	38.80
Cellulose (%)	36.17	32.80	35.36	35.36	22.13
Hemicellulose (%)	24.99	25.81	25.90	28.54	10.85
Lignin (%)	2.08	2.05	3.30	2.66	8.85
Source: Laboratorium of Chemical Feed and Nutrition, Hasanuddin University. NFE = Nitrogen-free extract.					

Table 1 indicated that those of all grasses studied contain a good and similar amount of nutrient content which could be used as a good protein and energy sources for ruminant. There is similarity in the nutrient content between one and another grass studied except rice bran. Rice bran used in this experiment tended to contain lower crude protein, but higher dry matter and ash content. A good quality of feed and contain

high amounts protein and energy sources is important to support optimum growth of rumen microbes as well as the maximum degradability of the feed in the rumen (Siregar, 2007; Soeparno, 1994). The result of feed voluntary intake measurement can be seen in Table 2.

Table 2
Average of feed voluntary intake of goat fed GP diet

Goat	DM intake as fed basis (g/d)	DM intake (g/d)	OM intake as fed basis (g/d)	CP intake as fed basis (g/d)
Goat-1	1242	500.12	1069.80	151.92
Goat-2	1157	465.75	996.29	141.48
Goat-3	1050	422.83	904.48	128.45
Goat-4	1125	452.99	968.99	137.61
Average	1144	460.42	984.89	139.87
Note: DM = dry matter, OM = organic matter, and CP = crude protein.				

Table 2 showed that the average feed voluntary intake of goat fed GP (general purpose) diet was 460.4 g/head/d, that means that all goat consumed total feed of about 3% from their body weight. Dry matter intake of about 3% from their body weight is just about a standard dry matter requirement of ruminant (Tilman *et al.*, 1999). Total dry matter intake by ruminant might be affected by several factors such as body weight, feed quality, palatability, and the energy content of the feed consumed (Parakassi, 1999; Cruch and Fontenot, 1979; Kamal, 1999). Whereas the crude protein requirement of goat of about 14kg live weight is 12–14% of total diet consumed (Kearl, 1982). The results measurement of four grasses studied at 4, 8, 12, 24, 48, and 72 hours after incubation in the rumen of goat is shown in Table 3.

Table 3
Dry matter loss (%) of four grasses in the rumen of goat

Incubation time (h)	Elephant grass	Mini elephant grass	<i>Panicum maximum</i> grass	<i>Brachiaria decumbens</i> grass
4	6.51 ^a	7.99 ^a	5.94 ^a	7.71 ^a
8	14.85 ^{ab}	15.76 ^{bc}	13.83 ^a	16.51 ^c
12	22.58 ^{ab}	23.58 ^b	22.07 ^{ab}	20.87 ^a
24	33.98 ^b	34.04 ^b	32.59 ^{ab}	31.24 ^a
48	52.84 ^c	53.18 ^c	49.60 ^b	42.68 ^a
72	55.73 ^b	55.61 ^b	53.25 ^b	46.10 ^b
Source: The result of experiment <i>in sacco</i> .				

Table 3 indicated that the DM loss of all grass studied increased as time of incubation time increased. The DM loss at 8, 12, 24, and 46 hours after incubation are significantly difference ($p < 0.05$) between four grasses. But there is no significantly difference ($p > 0.05$) in the DM loss between four grasses at 4 and 72 hours after incubation. There is significantly difference ($p < 0.5$) in the DM loss at 8, 12, 24, and 48 hours after incubation. *Brachiaria decumbens* (BD) grass tended to have DM loss lower than that of 3 other grasses. Although BD grass tended to contains higher nutrient it seems that those of nutrient content have been degraded and fermented slowly than that of 3 other grasses. This is confirmed by the results of degradation curve of the BD grass in the rumen of goat (see Fig. 1). Ørskov (1992) stated that the optimal degradation and fermentation of roughages in the rumen is about 48 to 72 hours. The higher the DM degradation of the roughages in the rumen indicated the higher quality of the roughages consumed by ruminant (Yusmadi, 2008).

The results measurement of characteristics degradation of the grasses in the rumen can be seen in Table 4.

Kurva degradasi BK = DM degradation curve, BK loss = DM loss, Masa inkubasi = Time of incubation (hours). Elephant grass (R1), Mini elephant grass (R2), *Panicum maximum* grass (R3) and *Brachiaria decumbens* grass (R4).

Table 4
DM Characteristic degradation of four grasses in the rumen of goat

Grasses	Characteristics degradation				
	a	b	a + b	c	Lag Time
Elephant grass	9.88 ^c	50.41 ^c	60.29 ^c	0.039	5.5 ^c
Mini elephant grass	16.50 ^d	44.99 ^b	61.49 ^c	0.038	8.3 ^d
<i>Panicum maximum</i> grass	7.42 ^b	49.64 ^c	57.06 ^b	0.040	4.5 ^b
<i>Brachiaria decumbens</i> grass	6.79 ^a	40.63 ^a	47.42 ^a	0.045	3.0 ^a
Note: Difference superscripts in the same columns indicated significantly difference ($P < 0.05$).					

Table 4 showed that there was significantly difference ($p < 0.05$) in the value of soluble materials (a) between the grasses. Mini elephant grass contains higher soluble materials compared to that of 3 other grasses. Whereas *Barchiaria decumbens* grass contains lowest soluble materials (6,7%). One of the factors affected the soluble value (a) might be the cells content of the grasses, the higher the cells content the higher the soluble materials of the grasses (Van Soest, 1982). The value of b (potential but slowly degradable materials) of the grasses were significantly difference ($p < 0.05$) between the grasses. *Barchiaria decumbens* grass contains lowest b value, while Elephant grass contains highest b value. This might be due to the difference content of ADF and NDF in the four grasses (Wati *et al.*, 2012). Elephant grass contains ADF and NDF 66.2% and 41.2% respectively. Whereas Mini elephant grass contains ADF

and NDF 62.7% and 36.9%, *Panicum maximum* grass contains 68.1% and 42.2%, and BD grass contains 68.2% and 39.7%, respectively. NDF contains hemicellulose which be easily degraded in the rumen but ADF contains cellulose, lignin, silica which hardly degraded by rumen microbes (Hakim, 1992). The strong cellulose lignin bond could likely inhibit the microbial degradation in the rumen of goat (Zakariah *et al.*, 2016).

There is no significantly difference ($p < 0.05$) in the rate of feed degradation in the rumen of goat. The rate and extension of feed degradability were similar between those of four grasses where BD grass 4.5% per hour, followed by *Panicum maximum* grass 4% per hour, Elephant grass 3.9% per hour, and Mini elephant grass 3.8% per hour. This in line with previous study *in sacco* reported by Sjamsuddin Rasjid and Ismartoyo (2014). There are significantly differences ($p < 0.05$) in the lag-t between four grasses as shown in Table 4. Rumen microbes takes longer time (8.3 hours) to adapt to the presence of and to start degrade Mini elephant grass compared to that of by *Panicum maximum* grass 4.5 hours, Elephant grass 5.5 hours, and BD grass 3.0 hours. This might be due to the differences in the ADF content and its structure especially in the structure of cellulose-lignin bond between four grasses.

The degradability of crude protein in the rumen is very important factor in feed evaluation system in ruminant. As matter of fact often quality of feed depends on the crude protein content and its degradability in the rumen (Puastuti *et al.*, 2012). The results of this experiment (Table 5) indicated that there were significantly differences ($p < 0.05$) in the rate and extent of crude protein content between four grasses after incubation of 24, 48, and 72 hours. But at incubation of 4, 8, and 12 hours the degradability of crude protein in the rumen of goat was similar ($p > 0.05$) between four grasses.

Table 5
CP degradation of four grasses in the rumen of goat

Incubation time (hour)	Elephant grass (%)	Mini elephant grass (%)	<i>Panicum maximum</i> grass (%)	<i>Brachiaria decumbens</i> grass (%)
4	19.59	14.34	14.68	14.68
8	27.89	25.17	29.49	27.96
12	37.33	32.08	36.55	36.58
24	56.27 ^a	43.38 ^b	48.94 ^b	49.14 ^b
48	69.52 ^a	61.49 ^b	69.19 ^a	61.09 ^b
72	71.97 ^a	62.71 ^b	72.08 ^a	62.47 ^b
Note: Difference superscripts in the same rows indicated significantly difference ($P < 0.05$).				

The CP rumen degradability at 48 hours and 72 hours incubation of Elephant grass and *Panicum maximum* grass higher than that of Mini elephant grass and BD grass. Incubation time of 48 to 72 hours is ideal time for rumen microbes feed degradation in the rumen (Gallo *et al.*, 2019). While after 24 hours

incubation the degradability of Elephant grass higher than that of 3 others grasses. This result suggested that Elephant grass tended to have better CP rumen degradability compared to Mini elephant grass, *Panicum maximum* grass, and BD grass (see CP degradation curve in Fig. 2).

Kurva degradasi PK = CP degradation curve, PK loss = CP loss, Masa inkubasi = Time of incubation (hours). Elephant grass (R1), Mini elephant grass (R2), *Panicum maximum* grass (R3) and *Brachiaria decumbens* grass (R4).

Higher CP rumen degradability will increase the availability of rumen ammonia in the rumen which is important for optimum growth of rumen microbes (Franzolin dan Aves, 2010). Rumen ammonia is a good indicator for examine the CP degradability in the rumen (Riswandi *et al.*, 2015) the higher the rumen CP degradability the higher the rumen ammonia will be (Mushandri, 2022).

The CP characteristics feed degradation (a, b, c, a + b, and lag-t) in the rumen can be seen in Table 6.

Table 6
CP degradation of four grasses in the rumen of goat

Grasses	Characteristics CP degradation				
	a	b	a + b	c	Lag Time (t)
Elephant grass	9.88 ^b	64.37 ^{ab}	74.25 ^a	0.0550	1.2 ^b
Mini elephant grass	16.50 ^a	45.24 ^c	61.74 ^b	0.0460	4.2 ^a
<i>Panicum maximum</i> grass	7.42 ^c	68.24 ^a	75.66 ^a	0.0471	1.3 ^b
<i>Brachiaria decumbens</i> grass	6.79 ^d	56.19 ^b	62.98 ^b	0.0698	1.2 ^b
Note: Difference superscripts in the same columns indicated significantly difference (P < 0.05).					

Table 6 showed that the CP characteristics degradation in the rumen of goat except the rate of CP degradation (c) were significantly differences (p < 0.05) between four grasses studied. The quickly CP degradable materials (a) of the grasses which associated with water soluble materials (Baiti, 2012) were Mini elephant grass highest one and BD grass the lowest one. This suggested that Mini elephant grass contains more easily degradable CP materials than other grasses. In contrast BD grass contains the lesser readily CP degradable materials compared to that of 3 others grasses.

The slowly but potential materials of the CP grasses (b) were significantly differences (p < 0.05) between four grasses studied. *Panicum maximum* grass contains highest b value (68.2%) than that of Elephant grass (64.4%), Mini elephant grass (61.7%), and BD grass (62.9%). The differences in the b value between four grasses might be due to the differences in the crude protein content which strongly bound with components including lignin which resistant to rumen microbial degradation in the rumen (La Goffe, 1991; Widyobroto *et al.*, 1995).

There are no significant differences ($p > 0.05$) in the rate and extent (c) of CP degradability of four grasses in the rumen of goat (Table 6). This suggested that CP content in those of four grasses were degraded in similar rate in the rumen of goat. This might be also due to the similarity in the nutrient content and the structure as well as cell's component of quickly degradable materials (Van Soest, 1994) of four grasses used in this experiment.

Total potential CP degradability (a + b) in the rumen of goat was significantly different ($p < 0.05$) between four grasses. The total potential CP degradability of *Panicum maximum* grass (75.6%) was highest one, followed by Elephant grass (74.2%), BD grass (62.9%), and Mini elephant grass 61.7%. Whereas lag-t of CP degradability of Elephant grass was the highest one (4.2 hours) compared to that of other grasses (Table 6). This suggested that the rumen microbes take longer time to start degrade CP content of Elephant grass than that of other grasses.

The results of this experiment also indicated that there is a good correlation ($r = 0.77$, $p < 0.05$) between DM degradability and DM feed intake. The DM intake is well known affected by the DM degradability in the rumen. The higher the DM degradability in the rumen the quicker the degraded materials left from the rumen hence the DM intake increased (Tomaszewska *et al.*, 1993; Usman, 2015). The CP degradability in the rumen was also have a good correlation ($r = 0.76$, $p < 0.05$) with CP intake by goat. The degradation and fermentation will enable rumen microbes to utilize non-protein nitrogen (NPN) as protein source of microbial protein which contains various amino acids needed by ruminant for production purposes (Hungate, 1996).

Conclusion

1. Although the degradability rate and extent of four grasses were similar, but other characteristics degradation in the rumen of goat such as a, b, a + b, and lag-t were significantly different between four grasses studied.
2. Total DM feed degradability at 72 hours of incubation the highest one was Elephant grass (55.73%) followed by Mini elephant grass (55.61%), *Panicum maximum* grass (53.25%), BD grass (46.10%).
3. Total CP feed degradability at 72 hours after incubation the highest one was *Panicum maximum* grass (72.06%) followed by Elephant grass (71.97%), Mini elephant grass (62.71%), and BD grass (62.47%).
4. The average of DM feed voluntary intake of goat fed GP diet was 460 g/head/day or of about 3.1% from live weight of goat used in this experiment.

Declarations

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Compliance with ethical standards Conflict of interest

The authors declare that they have no conflict of interest.

Author Contributions *All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Islamiyati, Muh. Rusdy and Andi Ikhsan Wijaya. The first draft of the manuscript was written by Ismartoyo and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.*

Data Availability *The datasets generated during and/or analysed during the current study are not publicly available due to all authors agreement and policy, but are available from the corresponding author on reasonable request.*

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Figures

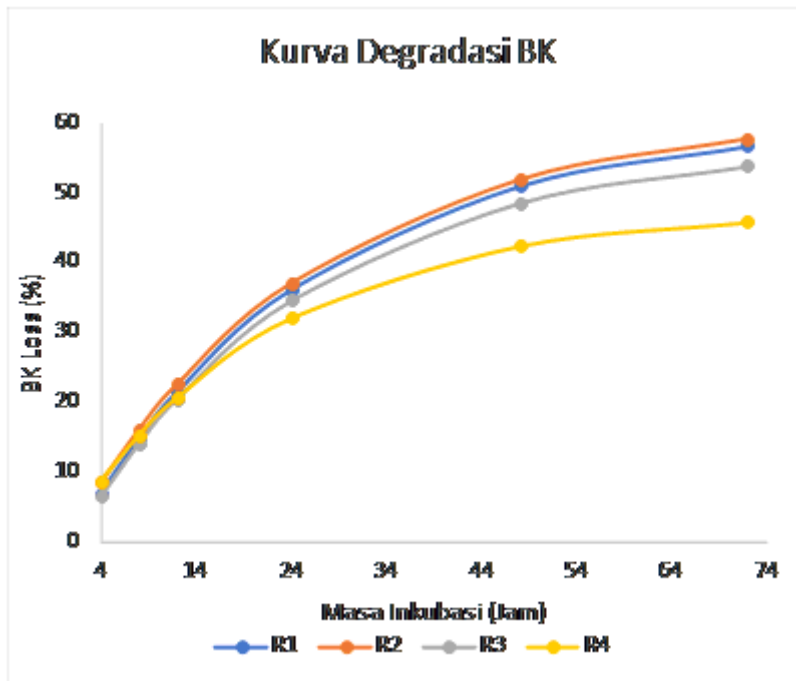


Figure 1

DM feed degradation curve of four grasses.

Kurva degradasi BK=DM degradation curve, BK loss=DM loss, Masa inkubasi=Time of incubation (hours). Elephant grass (R1), Mini elephant grass (R2), *Panicum maximum* grass (R3) and *Brachiaria decumbens* grass (R4).

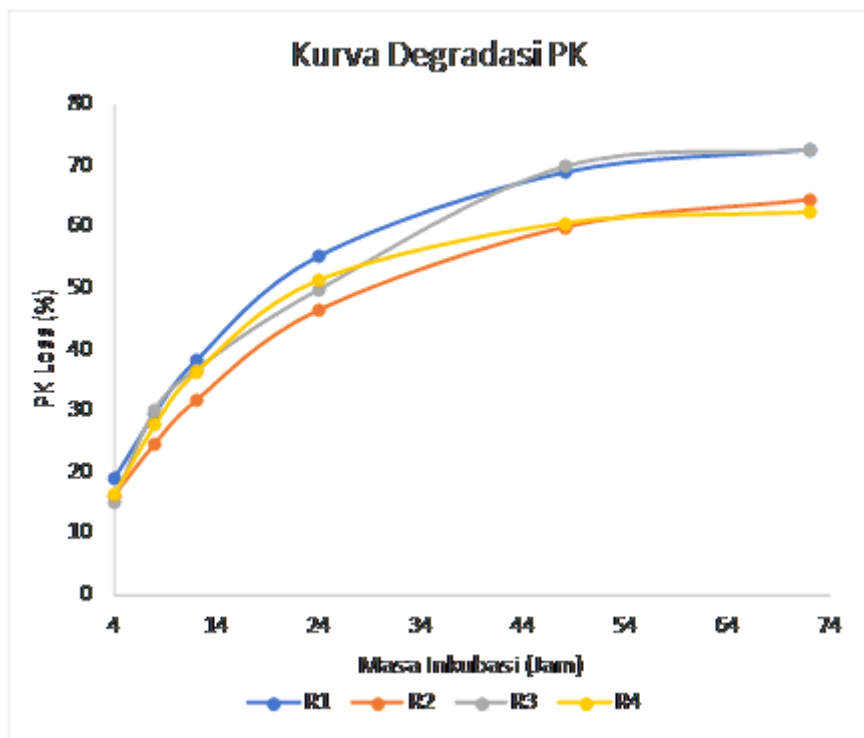


Figure 2

CP feed degradation curve of four grasses.

Kurva degradasi PK=CP degradation curve, PK loss=CP loss, Masa inkubasi=Time of incubation (hours). Elephant grass (R1), Mini elephant grass (R2), *Panicum maximum* grass (R3) and *Brachiaria decumbens* grass (R4).