Effect of Different Drying Method and Maturity of Mulberry (*Morus alba*) Hay on *In Situ* Degradability of Sheep

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ABSTRACT

The experiment was conducted to elucidate the characteristics of the mulberry hay with respect to *in situ* degradation of dry matter (DM) and crude protein (CP). Four types of diets were used in the study differentiated by the drying methods and maturity of mulberry. These are, Mulberry harvested at 5 weeks of age and oven-dried (MHO5); Mulberry harvested at 7 weeks of age and oven-dried (MHO7); Mulberry harvested at 5 weeks of age and sun-dried (MHS5); Mulberry harvested at 7 weeks of age and sun-dried (MHS7). Samples (MHO5 and MHO7) were dried in the oven at 60°C for 48 h. Meanwhile, samples (MHS5 and MHS7) were directly dried in the sun until they reached a constant weight. Three rumen-fistulated mature sheep of 2.5 to 3 years old and average weighed 37±2.0 kg were used in this experiment. The sheep were kept in individual pens and fed twice daily in equal meals at 09:00 and 17:00 h and free access to water. The diet of the animals consisted of 30% mulberry hay (DM basis) and 70% of oil palm frond (OPF) (DM basis). The DM degradation of MHO5 and MHS5 was significantly ($P<0.05$) higher than MHO7 and MHS7 at 12, 24, 36 and 48 h of rumen incubation**.** Meanwhile, the CP degradation of MHO5, MHS5, MHO7 and MHS7 was not significantly ($P>0.05$) different at 0, 6, 12, 24, 36 and 48 h of incubation. The degradability of water insoluble (b), potential degradability (PD) and effective degradability (ED) of DM of MHO5 and MHS5 were higher than MHO7 and MHS7. Meanwhile, the PD and ED of CP were significantly ($P<0.05$) decreased with advancing plant maturity. These suggest that mulberry hay of five weeks maturity more fermentable and large potential for feeding sheep.

Key word: mulberry hay, degradability, maturity, sheep

INTRODUCTION

Mulberry hay of five weeks maturity contained higher CP and lower cell wall and lignin content than of seven weeks (Ali *et al.*, 2007). The nutritive value of forage could be predicted from their degradation characteristics as they are strongly correlated to voluntary intake as compared to *in vivo* or chemical composition (Tolera and Sundstol, 2001).

Accurate estimation of the nutritive value of feed is important in animal production. The *in sacco* or nylon bag technique is commonly employed to estimate the degradation characteristics (Nordkvist *et al.*, 1987) in particularly of protein and roughages and also for rumen environment studies (Ørskov and Shand, 1997). The bag technique is also a very robust and powerful tool to study several other aspects of nutrition in ruminants. The degradation characteristics of feeds, determined by the *in sacco* method, could be used in the predictions of feed intake, digestibility and animal performance in terms of growth rate (Orskov and Ryle, 1990).

Studies on the degradation characteristic of fresh mulberry have been of great interest. Schmidek *et al.* (2002b) reported that mulberry leave showed high values of the soluble and potentially degradable fraction as well as the potential and effective degradation. It shows that mulberry foliage has a considerable potential for feeding ruminant.

The objective of this experiment was to elucidate the characteristics of mulberry hay with different drying and maturity respect to the *in situ* degradation of DM and CP.

MATERIALS AND METHODS

Experimental Diets

Four types of diets were used in the study differentiated by the drying methods and harvesting age of mulberry. These are:

MHO5 : Mulberry harvested at 5 weeks of age and oven-dried.
MHO7 : Mulberry harvested at 7 weeks of age and oven dried.
MHS5 : Mulberry harvested at 5 weeks of age and sun-dried.
MHS7 : Mulberry harvested at 7 weeks of age and sun-dried.

Samples (MHO5 and MHO7) were dried in the oven at 60°C for 48 h. Meanwhile samples (MHS5 and MHS7) were distributed and laid on a wooden frame tray (size: 3 m^2) covered underline with a fine plastic netting and directly dried under the sun until they reached a constant weight. The nutrient composition of the samples is shown in Table 1.

Table 1. Nutrient compositions (% DM) of MHO5, MHO7, MHS5 and MHS7

Nutrient	MHO 5	MHO 7	MHS 5	MHS 7
Dry matter (%)	90.6	91.1	89.6	87.6
Ash (%)	9.5	9.9	8.8	9.3
Crude protein (%)	24.3	21.9	24.1	21.1
Neutral detergent fiber (%)	40.8	44.4	43.1	45.6
Acid detergent fiber (%)	27.7	32.1	28.0	33.4
Acid detergent lignin (%)	4.6	6.4	4.9	6.3

Table 2. Nutrient composition (%DM) of the basal diet fed to the canulated sheep

Nutrient	OPF	Mulberry hay
Dry matter (%)	98.4	96.4
Ash (%)	6.1	8.6
Crude protein (%)	4.5	20.4
Neutral detergent fiber (%)	82.3	47.2
Acid detergent fiber (%)	63.9	29.9
Acid detergent lignin (%)	14.2	6.9

Animals and Diets

Three rumen-fistulated mature sheep of 2.5 to 3 years old and average weighed 37±2.0 kg were used in this study. The sheep were kept in individual pens and fed twice daily in equal meals at 09:00 and 17:00 h and free access to water. The diet of the animals consisted of 30% mulberry hay (DM basis) and 70% of oil palm frond (OPF as DM basis). The nutrient composition of the basal diet is shown in Table 2.

Experimental Design

The experiment was conducted in randomized complete block design with four treatments (MHO5, MHO7, MHS5 and MHS7) and three blocks (sheep). The sheep were adapted to the diet for 15 days. The degradation study was conducted for 7 days. In the rumen of each sheep, a total of four bags were put (four treatments). The bags were put in the rumen immediately before feeding in the morning (08:00 am).

Measurements of Degradation

Approximately 5 g of each sample (MHO5, MHO7, MHS5 and MHS7) were weigh and placed into the nylon bags (size 15 x 9 cm, pore size 45 µm) and then incubated in the rumen of fistulated sheep for 0, 6, 12, 24, 36 and 48 h. At the end of each incubation time the bags were removed from the rumen and washed in washing machine until the rinsing water was clear. All bags were then dried to constant weight at 60°C, and then analyze for DM and CP. The DM and CP were determined according to the methods of AOAC (1990). The bags for 0 h was not incubated in the rumen but washed directly in the washing machine until the rinsing water was clear.

The degradation characteristics of the samples were determined by using the NEWAY program based on the equation of :

$P = a + b (1- e^{-ct})$ (Orskov and McDonald, 1979).

where,

P: the degradation after t hours
a: the rapidly-soluble fraction at zero time,
b: the amount which in the time will degrade,
c: the degradation rate constant and
t: the incubation time

Statistical Analysis

Data on DM and CP degradation and degradation characteristics of the four treatments (MHO5, MHO7, MHS5 and MHS7) were analyzed by a completely randomized design using General Linear Models (GLM) procedure (SAS, 1997) and compared using Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Dry Matter Degradation

Table 3 shows the DM degradation of MHO5, MHO7, MHS5 and MHS7. The DM degradation was rapid with increasing time of incubation, particularly up to 12 h. The DM degradation was relatively constant after 12 h of incubation. At 0 and 6 h time of incubation DM loss was not significantly (P>0.05) different for all treatments.

The DM degradation of MHO5 and MHS5 was significantly (P<0.05) higher than MHO7 and MHS7 at 12, 24, 36 and 48 h of incubation. Meanwhile, DM degradation of Mulberry hay was not influenced by the method of drying. Table 4 shows the degradation characteristics of DM of MHO5, MHO7, MHS5 and MHS7. The soluble fraction (a) was no significantly (P<0.05) different for all treatments. The highest degradation of water insoluble (b) value was obtained in MHS5 followed by MHO5, MHS7 and MHO7. The degradation rate (c) was not significantly (P>0.05) different for all treatments.

The highest potential degradability (PD) was recorded in MHO5 followed by MHS5, MHS7 and MHO7. The highest effective degradability (ED) was obtained in mulberry of 5 weeks stage of maturity i.e. MHO5 (65.9%) and MHS5 (65.8%). There were significant decreased (P<0.05) for "b", "PD" and "ED" values with advancing maturity but not significantly (P>0.05) different with the drying methods.

Crude Protein Degradation

Table 5 shows the CP degradation of MHO5, MHO7, MHS5 and MHS7. The CP degradation increased with increasing time of incubation particularly up to 12 h, after that it tended to plateau. The CP degradation for all samples was not significantly (P>0.05) different at 0, 6, 12, 24, 36 and 48 h of incubation.

The slow degradation was recorded after 24 h of incubation. The CP degradation was not significantly (P>0.05) different with advancing maturity and method of drying at all time of incubation.

Table 6 shows the degradation characteristics of CP of MHO5, MHO7, MHS5 and MHS7. The highest soluble fraction (a) was obtained for MHO5 followed by MHS5, MHS7 and MHO7. There were significantly decreased (P<0.05) with advancing stage of maturity at oven drying but not significant (P>0.05) different at sun drying. The highest degradation of water insoluble (b) obtained in MHO7 followed by MHS7, MHS5 and MHO5.There was no significant (P>0.05) difference for "b" and "c" value with advancing maturity and drying method. The highest "PD" was obtained for foliage of five weeks stage of maturity compared with seven weeks stage of maturity. The "PD" value was significantly (P<0.05) decreased with advancing stage of maturity by oven drying, but not significantly (P>0.05) different by sun drying methods. The "ED" value was not significant (P<0.05) difference by drying method, but significant (P<0.05) different with advancing maturity.

Table 3. Degradation of DM (%) of MHO5, MHO7, MHS5 and MHS7 incubated in sheep

Samples	Time of incubation (h)					
	0	6	12	24	36	48
MHO5	25.6 ± 1.4	45.7 ± 6.4	74.1 ± 6.2^{a}	83.1 ± 1.4^{a}	83.5 ± 1.0^{a}	83.5 ± 1.7^{a}
MHO7	23.4 ± 0.9	47.3 ± 5.6	68.0 ± 5.5^{b}	77.0 ± 2.4^{b}	78.0 ± 0.9^{b}	78.2 ± 1.8^{b}
MHS5	24.4 ± 2.4	46.1 ± 3.1	74.3 ± 6.7^{a}	82.8 ± 0.7^{a}	83.3 ± 1.3^{a}	83.3 ± 0.8^{a}
MHS7	25.2 ± 2.5	45.3 ± 7.7	67.5 ± 7.7^{b}	77.8 ± 1.8^{b}	78.5 ± 0.9^{b}	79.8 ± 6.2^{b}
SEM	1.1	1.3	0.8	0.5	0.5	1.6

Note: a,b means with the different superscript within rows differ significantly (P<0,05). SEM: Standard Error of Mean.

Table 4. Degradation characteristic of DM of MHO5, MHO7, MHS5 and MHS7

Degradation Characteristics	MHO5	MHO7	MHS5	MHS7	SEM
a (%)	23.6 ± 2.3	22.4 ± 0.8	22.5 ± 1.9	23.6 ± 1.1	1.1
b (%)	62.4 ± 2.9^{p}	57.3 ± 1.7^{q}	63.2 ± 1.7^{p}	57.6 ± 2.1^{q}	1.3
c (fraction/h)	0.11 ± 0.02	0.12 ± 0.03	0.11 ± 0.02	0.10 ± 0.03	0.003
a+b (%)	86.0 ± 1.0^{p}	79.7 ± 1.0^{q}	85.7 ± 0.7^{p}	81.2 ± 1.0^{q}	0.4
Effective degradability (%)	65.9 ± 3.0^{p}	62.1 ± 3.1^{q}	65.8 ± 2.3^{p}	62.2 ± 3.8^{q}	0.4

Note: p,q means with different superscripts within rows differ significantly (P<0.05); SEM: Standard error of mean.

Table 5. Degradation of CP (%) of MHO5, MHO7, MHS5 and MHS7 incubated in sheep

Diets	Time of incubation (h)					
	0	6	12	24	36	48
MHO5	38.4 ± 1.2	56.9 ± 7.9	88.3 ± 7.0	95.7 ± 0.8	96.2 ± 0.3	96.4 ± 0.4
MHO7	24.3 ± 6.6	55.7 ± 6.0	86.1 ± 6.5	93.2 ± 1.3	94.7 ± 0.6	94.5 ± 0.4
MHS5	31.9 ± 3.3	56.6 ± 4.7	89.3 ± 6.0	96.0 ± 0.7	96.0 ± 0.5	96.8 ± 0.4
MHS7	27.3 ± 6.4	53.1 ± 5.0	84.5 ± 10.5	93.8 ± 1.4	94.4 ± 0.4	95.8 ± 1.2
SEM	3.3	2.8	1.31	0.2	0.2	0.3

Note: SEM = Standard error of mean.

Table 6. Degradation characteristic of CP of MHO5, MHO7, MHS5 and MHS7

Degradation Characteristics	MHO5	MHO7	MHS5	MHS7	SEM
a (%)	35.9 ± 1.9^{p}	22.8 ± 6.1^{q}	29.9 ± 2.7^{pq}	25.4 ± 6.9^{pq}	3.2
b (%)	63.2 ± 2.9	73.8 ± 5.5	68.8 ± 2.3	72.4 ± 6.4	4.3
c (fraction/h)	0.11 ± 0.03	0.13 ± 0.04	0.12 ± 0.02	0.11 ± 0.03	0.009
a+b (%)	99.1 ± 1.0^{p}	96.5 ± 0.6^{q}	98.8 ± 0.6^{p}	97.8 ± 0.7^{pq}	0.4
Effective degradability (%)	78.6 ± 3.6^{p}	75.3 ± 2.9^{q}	78.1 ± 2.5^{p}	74.9 ± 3.6^{q}	0.7

Note: p,q means with different superscripts within rows differ significantly (P<0.05); SEM: Standard error of mean.

This study showed that the DM and CP degradability of MHO5, MHO7, MHS5 and MHS7 were relatively constant after 12 h of rumen incubation. This is in agreement with Schmidek *et al.* (2002a) who obtained a high degradation rate within the first hours (6-12 h), followed by a stabilizing phase. The mean DM degradability of mulberry hay at five and seven weeks of maturity at 48 h of incubation was 83.4 and 79.0%, respectively. The degradability values were generally similar to the reported by Saddul (2005) with values of 83.9 and 81.9%, respectively, for fresh mulberry. The mean CP degradability of mulberry hay at five and seven weeks maturities were 96.7 and 95.2% that were also similar to the values of 96.3 and 96.2% as reported by Saddul (2005). Schmidek *et al.* (2002a) also found that the CP degradability of mulberry foliage at 48 h incubation was 96.8%. The result shows that the drying process did not influence the degradability of DM and CP of mulberry foliage.

The study showed that the plant maturity influenced the DM degradability. The DM degradability of MHO5 and MHS5 was higher than MHO7 and MHS7. This result is in agreement with findings of several researchers (Kawas *et al* (1990); Bal *et al* (2000); Akbar *et al.* (2002) and Kamalak *et al.* (2005) who found that DM degradability was significantly reduced with increasing maturity. Saddul *et al.* (2005) reported that the effect of plant maturity on degradation of mulberry might be associated with the corresponding increase in the structural fiber composition with advancing plant maturity. This may constitute a barrier for microbial attachment to the feed resulting in a decrease in degradability with advancing maturity. Increasing maturity of forage usually leads to higher cell wall content Akbar *et al.* (2002) and reduce CP and DM contents (Yu *et al.*, 2003). When forage mature the leaf:stem ratio declines (Jung and Engels, 2002). Stem contain more cell walls material than leaves and degradability of cell walls by ruminant are lower than cell soluble components (Buxton and Brasche, 1991). Meanwhile, the CP degradability was not significantly different with advancing maturity. This result is in agreement with the finding of Balde *et al.* (1993) and Chaves *et al.* (2006).

The "b", "PD" and "ED" values of dry matter of MHO5 and MHS5 were higher than of MHS7 and MHO7, this may be due to the increase in fiber constituents with maturity (Akbar *et al.*, 2002). Kamalak *et al.* (2005) also reported that the DM degradation and degradation characteristic was significantly reduced with increasing maturity. The soluble (a) value of crude protein of MHO5 and MHS5 were higher than MHO7 and MHS7, and this indicate that the rapid degradation fraction of CP was not influenced by plant maturity. This result was consistent with the reports of Balde *et al* (1993); Kamalak *et al.* (2005) and Saddul (2005) who found a significant decline in the soluble a fraction of CP with advancing stage of maturity. The PD and ED of CP of mulberry hay were significantly (P<0.05) decreased with advancing stage of maturity. This result is similar with reported by Balde *et al.* (1993) who found that PD and ED of CP of alfalfa decreased with increasing maturity.

CONCLUSIONS

The DM degradability of mulberry hay was significantly decreased with advancing plant maturity from five weeks to seven weeks and the CP degradability was not influence by advancing plant maturity. Mulberry hay at five weeks old offers higher effective and potential degradability than seven weeks old. These suggest that mulberry hay at five weeks maturity more fermentable and large potential for feeding sheep.

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