Bulletin of Animal Science, Supplement Edition, 1998 *ISSN 0126-4400*

RUMEN DEGRADABILITY OF THE UPPER AND LOWER PARTS OF UNTREATED OR UREA TREATED RICE STRAW VARIETIES

Dwi Yulistiani[1], J.R. Gallagher[2] and R. van Barneveld[3]

ABSTRACT

A study to evaluate the digestibility of the upper and lower parts of rice straw varieties and the effect of urea treatment was conducted using a rumen degradability (*in sacco*) study. Straw from four varieties of rice (Dong, Ilb, Yrl and Yrm) were separated in upper and lower parts and were treated with 4% urea. The degradation characteristics of the straw were measured by incubating samples (in nylon bag) for 8, 16, 48 or 72 hours in the rumen of four sheep fitted with rumen cannulae. The data were described using exponential equation $p= a+b(1-e^{-ct})$, where p=degradation loss, t=time, and a,b and c are constants. Dry matter degradability of the lower part was higher than the upper part for all varieties except for Ilb. Urea treatment improved the rumen degradability of rice straw, where the rate of degradation constant (c) of urea treated straw was significantly higher ($P<.05$) than untreated straw (0.045 vs 0.031 fraction/hour) and potential degradability (PD) of urea treated straw was significantly higher than untreated straw (632 vs 568 g/kg DM).

Key words : Rice straw, Varieties, Urea treatment, Rumen degradability

INTRODUCTION

Rice straw is a crop residue that is widely available in tropical countries (Ibrahim *et al.*, 1988). However, its nitrogen content and digestibility are too low to meet the nutrient requirements of ruminants. Urea has been used to treat straw, to increase its nutritive value (Williams *et al.*, 1984*a*).

The nutritive value of feeds is dependant upon nutrient concentration (chemical composition), digestibility and the level of voluntary intake (Ibrahim ,*et al.*, 1989). The voluntary intake of low quality feeds, such as straw, is governed by the amount of material in the reticulo rumen (both degradable and undegradable), the rate of digestion and the rate of passage of digesta out of the reticulo-rumen. Rumen degradation studies provide information on both degradable and undegradable fractions of the feeds and also the rate of degradation (Ibrahim *et al.* 1989).

Little work has been reported on the aspects of rumen degradability of rice straw and its upper and lower parts or the effect of urea treatment. Therefore, the objectives of this study were to see if there were differences in the degradation characteristics of the upper and lower parts of four varieties of rice straw and to observe the effects of urea treatment on degradability.

MATERIALS AND METHODS

Animals and diets

Four, South Australian Merino sheep of 50 kg live weight fitted with rumen fistula were used for the experiment. The sheep were fed a maintenance ration (1.2 kg DM/day) which consisted of 50% oaten chaff and 50% lucerne chaff. This was fed in equal meals each day at 0900 and 1700.

[1] Research Institute for Animal Production. PO Box 221 Bogor
[2] Department of Animal Science, The University of Adelaide
[3] Pig and Poultry Production Institute, South Australia

Straw

Four, semi-dwarf varieties of rice straw were obtained from the Yanco Agricultural Institute, Yanco, Leeton, N.S.W. Doongara (Dong), Illabong (Ilb), YRL-39 (Yrl) and YRM-43 (Yrm) straws were divided equally by length into upper and lower parts and dried in a forced draught oven at 60 °C for 48 hours. Dried straws were then chopped into three cm lengths. A sub-sample of the chopped straws was then ground in a laboratory hammer mill with a 1mm screen. Ground samples were stored in air-tight containers prior to chemical analysis and an *in vitro* digestibility study.

For urea treatment, 200 g samples of chopped straw from each part of each variety were prepared by spraying with urea solution and mixing thoroughly to provide urea and moisture levels of 40 g/kg and 400 g/kg of dry matter respectively. Treated straws were then kept in air-tight plastic bags at 22 °C for six weeks. The bags were then opened and the contents dried at 50-60 °C for 48 hours (Ibrahim *et al.*, 1988). Ungrounded samples of untreated and urea treated straw were ground through a 1mm screen used for chemical analysis and a 2.5 mm screen used for nylon bag studies.

Chemical analysis

Dry matter (DM), organic matter (OM) and nitrogen (N) content of the samples were determined using the methods of the AOAC (1990). Neutral detergent fibre (NDF), acid detergent fibre (ADF), permanganate lignin and silica (insoluble ash) were determined using the methods of Goering and Van Soest (1970). Hemicellulose (HC) was calculated by subtracting ADF from NDF values (Goering and Van Soest, 1970).

Determination of degradation characteristics

The dry matter losses (DML) of

Table 1. Chemical composition (g/kg DM) for four varieties of rice straw and their parts either untreated (U) or treated with urea (TU)

		Chemical composition					
		N	NDF	ADF	Lignin	Silica	HC
Dongara							
Upper	U	10.3	738.6	534.2	59.6	138.4	204.4
	TU	18.6	705.5	548.9	61.7	130.7	156.7
Lower	U	7.4	653.2	484.8	49.5	115.7	135.0
	TU	15.5	680.7	545.7	69.8	115.7	135.0
Ilb							
Upper	U	9.7	685.8	557.8	82.4	132.3	128.0
	TU	18.4	695.0	567.7	83.4	124.2	127.3
Lower	U	5.8	745.2	626.3	80.0	139.8	118.9
	TU	20.0	722.2	615.1	75.1	144.2	107.1
Yrl							
Upper	U	8.7	749.3	573.0	71.3	121.1	176.3
	TU	17.9	742.8	601.1	76.4	124.9	141.8
Lower	U	5.8	704.2	556.5	63.2	121.1	176.3
	TU	17.1	719.8	571.6	63.8	124.9	148.2
Yrm							
Upper	U	11.1	735.5	565.7	70.2	154.9	169.7
	TU	18.2	730.6	583.3	74.7	134.9	147.3
Lower	U	8.3	693.5	571.0	59.9	142.7	122.5
	TU	16.8	709.8	597.7	67.6	148.5	112.2

Table 2. Mean values of mean factor effect of variety, part and urea treatment on washing loss and degradability characteristics *in sacco* of rice straw according to the equation $p = a+b(1-e^{ct})$.

	Washing Loss (g/kg DM)	Degradation characteristics			
		a (g/kg DM)	b (g/kg DM)	c (fraction/h)	PD (a+b) (g/kg DM)
Variety					
Dong	258[a]	249	372	0.039	622
Ilb	233[b]	225	348	0.043	573
Yrl	223[c]	209	398	0.033	607
Yrm	225[c]	219	380	0.036	599
s.e.	4.1	8.12	14.47	0.0037	7.03
significance	**	N.S.	N.S.	N.S.	N.S.
Part					
upper	220	210	404	0.032	614
lower	250	241	346	0.044	586
s.e.	2.9	5.74	10.21	0.0026	4.97
significance	**	*	*	N.S.	*
Treatment					
untreated	223	213	355	0.031	568
urea treated	246	238	395	0.045	632
s.e.	2.9	5.74	10.21	0.0026	4.97
significance	**	N.S.	N.S.	*	**

a = immediately soluble material
b = insoluble but degradable material
c = the rate degradation of b material
PD = (a+b) potential degradability
**, P<.01; *, P<.05; N.S., non significance

straw samples when incubated in nylon bags, *in vivo* were determined as described by Mehrez and Ørskov (1977). About 2 g of air dry samples were incubated in nylon bags suspended in the rumen for 8, 16, 24, 48 or 72 hours. The bags were incubated using the serial addition method that allowed removal of all bags at the same time. Each of the parts from each variety was incubated separately in the rumen of each sheep for each incubation period. Their degradation characteristics were described by the exponential equation of Ørskov and McDonald (1979);

$$p = a+b(1-e^{-ct}),$$

where :

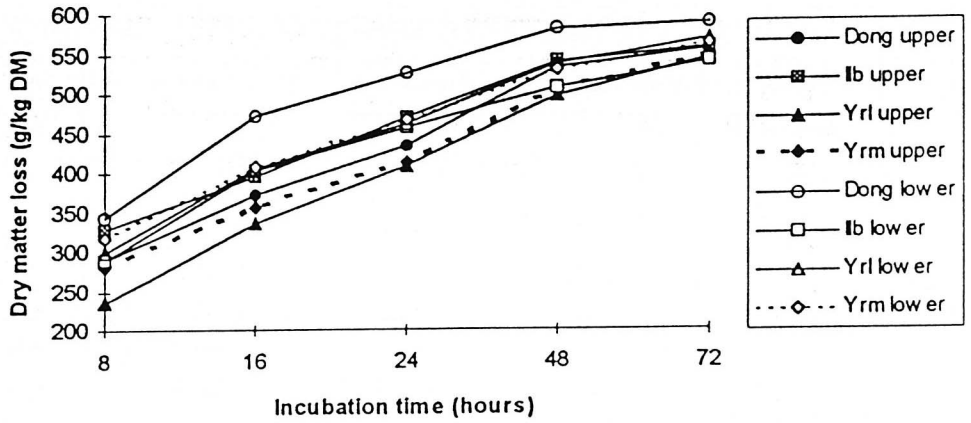
p = degradation at time t and a, b, c are constants defining the degradation characteristics of the sample.

Constant:

a = the intercept, and equals the immediately soluble material.
b = the insoluble but degradable material
c = the rate of degradation of b material
(a+b) = the potential degradability of the straw (PD)

Washing loss (solubility) without incubation in the rumen was determined by measuring dry matter loss caused by soaking samples contained in the nylon bags in water at 30 °C for 30 minutes and then washed

Figure 1. Dry matter loss of the upper and lower parts of rice straw varieties.



under running tap water until the water was colourless. The bags withdrawn from the rumen were also washed in the same manner, before being dried to constant weight at 60 ^{o}C.

Statistical analysis

The experiment used a 4 x 2 x 2 factorial design involving 4 straw varieties, upper and lower parts and either untreated or urea treated straw. The values of washing loss, DML (dry matter loss) and degradation characteristics were analysed by analysis of variance using Genstat 5 (Lawest Agricultural Trust, 1994).

RESULTS AND DISCUSSION

The chemical composition of the four varieties of rice straw and their parts either untreated (U) or treated with urea (TU) are presented in Table 1. The N, lignin, and HC content were higher in the upper part than in the lower part for all varieties. While the NDF, ADF and silica content were similar in both parts of all varieties. Urea treatment increased N content in both parts of all varieties. The increase only on N content after urea treatment is in agreement with the finding of Walli *et al.* (1988) who reported that ammonia treatment had little or no effect on other chemical composition except for crude protein content.

Washing loss and degradation characteristics for the straw varieties and their parts and the effect of urea treatment are shown in Table 2 and the degradation pattern for the variety and their parts at various incubation time is illustrated in Fig 1. There were significant differences ($P<.01$) in washing loss between varieties and between parts. The DML curves the upper and lower part of all varieties shows the lower part of Dong variety had the highest DML at various incubation time up to 48 hours (Fig 1). In the part, the lower part had higher washing loss and DML than the upper part (Table 2) this could be due to the lower part containing more stem than the upper part (42.3 vs 14.5%). This result is supported by Nakashima and Ørskov (1990) and Walli *et al.* (1988) who observed the stem internode more degradable than the leaf.

The degradation characteristics (a, b, c and PD values) were not significant between varieties. Even though there were no significant differences in immediately soluble material, insoluble but degradable material, rate of degradation and potential degradability between varieties it does not indicate that those varieties in this study had similar nutritive value, because Ørskov *et al.* (1988) observed degradation at 48 h was closely correlated with intake (r = 0.90).

Since there was an interaction between part and variety on degradation at 48 hours in this study it appeared that the lower part of the Dong variety might give higher intakes than other varieties and subsequently result in better animal performance. The differences in the rate of degradation constant (c) were not significant different between parts but the potential degradability (PD) and insoluble but degradable fraction (b) were significantly higher in the upper part than in the lower part. In contrast, Nakashima and Ørskov (1990) observed that the internode of rice straw had higher PD value.

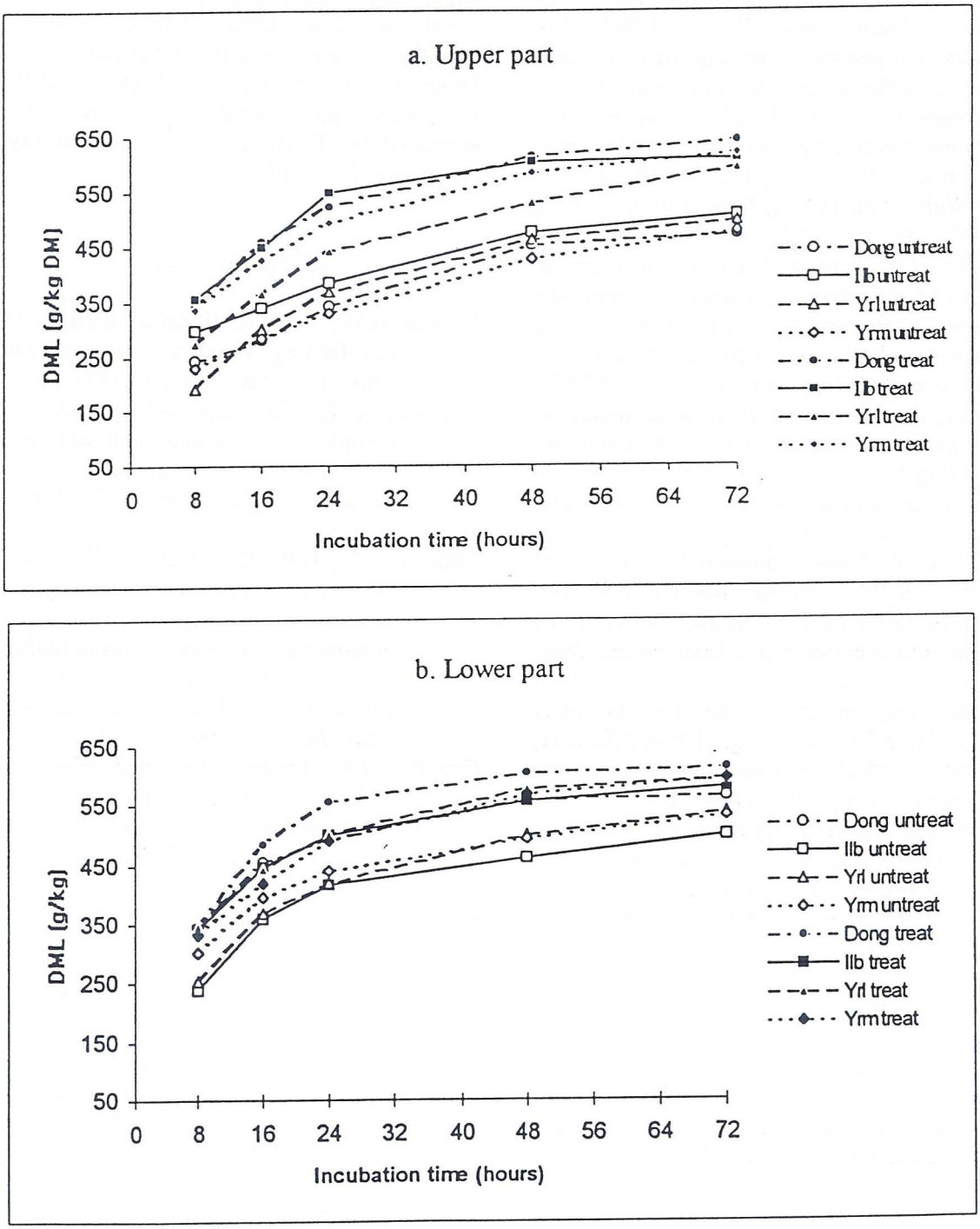


Figure 2. Effect of urea treatment and variety on dry matter loss of rice straw.

The effect of urea treatment on the DML of the upper and lower parts of all varieties is depicted in Fig 2. Urea treatment increased the washing loss (Table 2) and DML of both parts for all varieties at various incubation times. The increased solubilisation of low quality roughage materials in this case in treated rice straw is an indication of improved digestibility (Ololade *et al.*, 1970 and McManus and Chung, 1976). The interaction between parts and urea treatment was significant this is indicated by the increase in the DML of the upper after treatment with urea was higher in the upper part than in the lower part. Previous studies by Walli *et al.* (1988), Kernan *et al.* (1979), Hartley *et al.* (1984), and Nakashima and Ørskov (1990) showed that the increased in DML of rice straw after urea treatment was greater in the leaf than in the stem. In the current study, the upper part contained more leaf than the lower part (63.5% vs 47.8%) hence, the increase in DML after treatment was greater for the upper part than the lower part (Fig 4.3). The greater DML after urea in the upper part may be due to the higher HC level part (155 vs 142 g/kg) and lignin levels (67.9 vs 61.9 g/kg) compared to the lower part. In the secondary lignified cell wall such as those found in straw, the nature of cross linking between structural carbohydrate and lignin means more HC is bound to lignin, and therefore, the HC becomes unavailable for rumen degradation (Chesson, 1988). Alkali treatment such as urea treatment disrupt the ester bond between lignin and HC, resulting in the HC becoming available for digestion (Chesson, 1988).

The effect of urea treatment on the degradation characteristics was significant ($P<.05$) in increasing potential degradability (PD) and was highly significant ($P<.01$) in increasing the rate of degradation constant (c) of the treated straw. The increase in the rate of degradation constant represent an increase in rumen flow from the gut, resulting in an increase in roughage consumption (Ibrahim *et al.* 1989). Since rumen degradability and apparent digestibility *in vivo* correlated with intake, voluntary intake should be correlated with the rate of degradation constant (c). Because of the rate of degradation value of urea treated straw was higher than untreated straw it could be expected that the intake of treated straw would be higher. The increase potential degradability and the rate of degradation resulting from urea treatment has also been reported by Ibrahim *et al.* (1989).

From the results this study it can be concluded that DML varied between varieties and part, with the lower part of the Dong variety having the highest DML compared to other varieties. Urea treatment increased the DML, potential degradability and rate of degradation.

REFERENCES

Capper, R.B.S. (1988). Genetic variation in the feeding value of cereal straw. *Anim. Feed Sci. Tech.*, 21:127-140.

Chesson, A. (1988). Lignin-Polysaccharide complexes of the plant cell wall and their effect on microbial degradation in the rumen. *Anim. Feed Sci. Tech.*, 21:219-228.

Colucci, P.E., Falk, D., Macleod, G.K. and Grieve, D.G. (1992). In situ organic mattter degradability of untreated and urea-treated varieties of spring barley and oat straws, and of untreated varieties of winter wheat straws. *Anim. Feed Sci. and Tech.*, 37:73-83.

Coombe, J.B., Dinius, D.A. and Wheeler, W.E. (1979). Effect of alkali treatment on intake and digestion of barley straw by beef steer. *J. Anim. Sci.*, 49:169-176.

Doyle, P.T, Devendra, C. and G.R. Pearce (1986). Rice Straw As Feed For Ruminants. IDP. Canberra .

Givens, D.I., Adamson, A.H. and Cobby, J.M. (1988). The effect of ammoniation on the nutritive value of wheat, barley and oat staws. II. Digestibility and energy value measurements in vivo and their prediction from laboratory measurements. *Anim. Feed Sci. and Tech.*, 19:173-184.

Hartley, R.D., Deschard, G., Keene, A.S. and Mason, V.C. (1984). Changes in the chemical constitution of cereal straw and poor quality hay during upgrading. In 'Improvements in the nutritive value of crop by-products by chemical or biological treatments'. Proceeding of 2nd Seminar on the Up-grading of Crops and By-products, Hurtley, pp. 11-14. Ministry of Agriculture, Fisheries and Food, London.

Hovell, DeB.F.D., Ngambi, J.W.W., Barber, W.P. and Kyle, D.J. (1986). The Voluntary intake of Hay by sheep in relation to its degradability in the rumen as measured in nylon bags. *Anim. Prod.*, 42:111-18.

Ibrahim, M.N.M., S. Taminga and G. Zemelink, (1989). Effect of urea treatment on rumen degradation characteristics of rice straw. *Anim. Feed Sci. Tech.*, 24:83-95.

Kernan, J.A., Crowle, W.L., Spurr, D.I. and Coxworth, E.C. (1979). Straw quality of cereal cultivars before and after treatments with anhydrous ammonia. *Can. J. Anim. Sci.*, 59:511-517.

Lawes Agricultural Trust (1994). *Genstat 5 Release 3.1.* Rothamstead Experimental Station. Clarendon Press, Oxford.

McManus, W.R. and Choung, C.C. (1976). Studies on forage cell walls. 2. Conditions for alkali treatment of rice straw and rice hulls. *J. Agr. Sci. Cambridge*, 86:453- 470.

Mehrez, A.Z. and Ørskov, E.R. (1977). A study of the artificial fibre bag technique for determining the digestibility of feeds in the rumen. *J. Agr. Sci. Cambridge*, 88:645-650.

Nakashima, Y. and Ørskov, E.R. (1990). Rumen degradation of straw. 9. Effect of cellulase and ammonia treatment on different varieties of rice straws and their botanical fractions. *Anim. Prod.*, 50:309-17.

Ololade, B.G., Mowat, D.N. and Winch, J.E. (1970). Effect of processing methods on the in vitro digestibility of sodium hydroxide treated roughages. *Can. J. Anim. Sci.*, 50:657-662.

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. Agr. Sci. Cambridge*, 92:499-503.

Ørskov, E.R., Reid, G.W. and Kay, M. (1988). Prediction of intake by cattle from degradation characteristics of roughages. Anim. Prod., 44:29-34.

Ramanzin, M., Ørskov, E.R., and Tuah, A.K. (1986). Rumen degradation of straw. 2. Botanical fractions of straw from two barley cultivars. *Anim. Prod.*, 46:29-34.

Schiere.J.B and Nell. A.J. (1993). Feeding of Urea Treated Straw in The Tropics. 1. Review of Its Technical Principles and Economics. *Anim. Feed Sci., and Tech.*, 43:135-147.

Walli, T.K., Ørskov, E.R. and Bhargava, P.K. (1988). Rumen degradation of straw. 3: Botanical fractions of two rice straw varieties and effects of ammonia treatment. *Anim. Prod.*, 46:347-352.

Williams, P.E.V., Innes, G.M. and Brewer, A. (1984*a*). Ammonia treatment of straw via the hydrolysis of urea. 1. Effects of dry matter and urea concentration on the hydrolysis of urea. *Anim. Feed Sci. and Tech.*, 11:103-114.