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M Ridla[1], M Dewi[2,3], E B Laconi[1] and A Jayanegara[1]

[1]Department of Nutrition and Feed Technology, Faculty of Animal Science, IPB University, Jl. Agatis Kampus IPB Dramaga Bogor 16680, Indonesia
[2]Graduate Study Program of Nutrition and Feed Science, Faculty of Animal Science, IPB University, Jl. Agatis Kampus IPB Dramaga Bogor 16680, Indonesia
[3]Politeknik Pertanian Negeri Payakumbuh, Jl. Raya Negara KM. 7 Tanjung Pati, Kabupaten Lima Puluh Kota, Sumatera Barat 26271, Indonesia

E-mail: anuraga.jayanegara@gmail.com

Abstract. This study aimed to compare between rice straw and urea-treated rice straw with regard to their chemical composition and degradation kinetics in the rumen by employing a modelling approach. Data were collected from various journal articles that comprised of chemical composition (crude protein [CP], neutral detergent fiber [NDF], acid detergent fiber [ADF] and lignin) and degradation kinetic parameters of organic matter (soluble fraction, degradable, undegradable, degradation rate and lag time). Comparison was performed by using a statistical mixed model methodology in which treatments (control vs urea-treated rice traw) were considered as fixed effects whereas different studies were considered as random effects. These data were then used as parameters to build a dynamic model of rice straw degradation in the rumen. Results showed that urea treatment increased CP ($P<0.001$) while decreased NDF ($P<0.01$) contents of rice straw. The ADF and lignin contents were similar between the control and urea-treated rice straw. Proportion of degradable fraction and degradation rate of rice straw were enhanced due to urea treatment ($P<0.001$). However, the treatment did not influence soluble fraction and lag time of the material. Microbial biomass and total volatile fatty acid production in the rumen changed dynamically over time and the values were higher for the urea-treated rice straw.

1. Introduction

Rice straw is a by-product from rice production. It is the leftover after rice plant is harvested for its grains. Typically rice straw is abundantly available in the country or region where rice is consumed as a main staple food for human, including in Indonesia. Despite its abundant availability, the nutritive value of rice straw is considered to be low, particularly characterized by the high lignocellulose fraction and the low protein content [1]. Such characteristics contribute to the low amount of nutrient that can be utilized by livestock and therefore lead to a low production performance of the livestock [2]. Furthermore, from the point of view of environmental conservation, the low nutritive value of rice straw may result in a high emission of methane, a major greenhouse gas contributing to the global warming problem and climate change [3].

Pre-treatment of rice straw is essential in order to enhance its nutritive value as well as to improve the productivity of livestock. Apart from these reasons, improvement of forage or diet quality may also mitigate enteric methane emission [4]. Urea treatment is among a reasonable and practical pre-treatment

option for increasing the nutritive value of rice straw. It has been practiced for many years by farmers particularly in the developing countries in order to ensure the sufficiency of forage provision during the whole year [5]. Although there have been numerous studies attempting to enhance the quality of rice straw through urea treatment, the results have been varied and there is a lack of study to integrate the findings quantitatively. This study therefore aimed to compare between rice straw and urea-treated rice straw with regard to their chemical composition and degradation kinetics in the rumen by employing a modelling approach.

2. Method

Data were collected from various journal articles that comprised of chemical composition (crude protein [CP], neutral detergent fiber [NDF], acid detergent fiber [ADF] and lignin) and degradation kinetic parameters of organic matter (soluble fraction, degradable, undegradable, degradation rate and lag time). In total, there were five articles used to develop the database [6–10] and comprised of 31 data points. After collection, different units of measurements within a particular parameter were transformed into similar units in order to allow direct analysis.

Comparison was performed by using a statistical mixed model methodology in which treatments (control vs urea-treated rice traw) were considered as fixed effects whereas different studies were considered as random effects. These data were then used as parameters to build a dynamic model of rice straw degradation in the rumen. The rumen dynamic model was according to our previous published study [11]. No weighting procedure was applied for different studies. Significance and tendency were declared when $P<0.05$ and $P<0.1$, respectively. When a variable showed significant difference at $P<0.05$ between various saponin levels. The mixed model was run by employing the SAS software version 9.1 whereas the dynamic model was run by using the Vensim PLE software version 6.3.

3. Results and discussion

Urea treatment increased CP content of rice straw ($P<0.001$) and decreased its NDF content ($P<0.01$), but had no effects on ADF and lignin contents (table 1). Soluble OM fraction was similar between the two treatments. Degradable OM and degradation rate constant of rice straw in the rumen were elevated through urea treatment ($P<0.001$). On the contrary, rice straw treated with urea had a lower undegradable OM than that of control ($P<0.001$). Urea treatment did not alter the lag time of rice straw degradation in the rumen. Microbial biomass and total volatile fatty acid production in the rumen changed dynamically over time and the values were higher for the urea-treated rice straw (data not shown).

Table 1. Effects of urea treatment on chemical composition and rumen degradation kinetics of rice straw

Parameter	Unit	Control	Urea treatment	SEM	P-value
CP	%	5.53	10.2	0.758	<0.001
NDF	%	73.6	72.0	1.27	0.002
ADF	%	43.8	44.4	1.29	0.302
Lignin	%	4.07	4.02	0.293	0.636
Soluble OM	%	10.2	10.1	0.968	0.937
Degradable OM	%	56.8	62.6	2.22	<0.001
Undegradable OM	%	33.2	27.3	1.75	<0.001
kd	%/h	2.47	3.18	0.136	<0.001
Lag time	h	3.98	3.61	0.605	0.263

CPD, crude protein; NDF, neutral detergent fiber; ADF, acid detergent fiber; OM, organic matter; kd, degradation rate constant; SEM, standard error of the mean.

Higher CP of rice straw due to urea treatment is expected since the compound is a non-protein nitrogen and thus adds substantial amount of N into the substrate [12]. The treatment is particularly effective to split up the hemicellulose fraction as indicated by the lower NDF. However, urea treatment is not effective to breakdown lignocellulose fraction since ADF and lignin were not altered by the

treatment. Although the magnitude of fiber decrease due to urea treatment is relatively small, substantial increase of OM degradation in the rumen may occur as also indicated by the degradation kinetic parameters in the present study. This is possible since urea treatment may expand the cell wall, allow cellulolytic microbes to colonize better and finally enhance the substrate degradation [2,12].

4. Conclusion

Urea treatment increases CP content of rice straw and decreases the NDF but at a small magnitude. The treatment is effective for improving substantially the OM degradation kinetics in the rumen.

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