animal production
ISSN 1411-2027 e-ISSN 2541-5875

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KEYWORDS
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ISSN 1411-2027 e-ISSN 2541-5875

Vol 14, No 3 (2012)

September

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Utilization of Spent Rice Straw Compost to Substitute Napier Grass Fed to Cattle and Its Effect on Rumen Metabolism Products

SNO Suwandyastuti and M Bata*

Faculty of Animal Science, Jenderal Soedirman University, Jl. Dr. Suparno 60, PO Box 110, Purwokerto 53123
Telephone +62-281-638792, Central Java, Indonesia
***Corresponding author email: muhamadbata@yahoo.com**

Abstract. The aim of this research was to find the optimum level of substitution of fresh Napier Grass with Spent Rice Straw Compost (SRSC) on rumen metabolism products. Two male cattle breeds consisted of indigenous cattle (Ongole Crossbred = OC) with average body weight of 78.48±7.69 kg and Fries Holland Crossbred (FHC) with body weight of 83.93±17.67 kg were kept in individual cages of 1x1.2 m and they were given four kinds of Napier Grass subtituted with SRSC of 0, 25, 50 and 75 percent of forage dry matter. Therefore, factorial experiment of 2x4 was used in this research. The dry matter ratio of forage and concentrate was maintained at 50:50% with total dry matter intake 3% of body weight. Total Volatil Fatty Acid (VFA) production were influenced by the breed of cattle and the body weight, but there was no significant effect of breed on the N-NH_3. Both average of VFA (122.92±3.22 mM/l) and N-NH_3 (4.14±0.4 mM/l) were still in the optimum range for rumen micoorganisme activities. Regression analysis showed that the digestibility of crude fiber had same pattern with acetate (C_2), propionate (C_3), butirate (C_4), and valerate (C_5). It can be concluded that SRSC can be used to substite fresh Napier Grass up to 75 percent of forage dry matter in the diets of male cattle both OC and FHC.

Keywords : spent compost, Volatile Fatty Acid, Nitrogen Ammonia

Abstrak. Tujuan penelitian ini adalah untuk menemukan level optimum susbsitusi rumput gajah dengan kompos jamur merang ditinjau dari produk-produk metabolisme rumen. Dua jenis bangsa sapi berkelamin jantan dari bangsa Peranakan Ongole (PO) dengan rataan bobot badan 78,48±7,69 kg dan bangsa sapi Peranakan Fries Holstein (PFH) dengan rataan bobot badan 83.93±17,67 kg dipelihara pada kadang individu dengan ukuran 1x1.2 m. Sapi-sapi tersebut diberi empat macam pakan subsitusi rumput gajah dengan kompos jamur merang dengan taraf 0, 25, 50 dan 75% dari bahan kering rumput. Penelitian ini menggunakan pola faktorial 2x4. Imbangan bahan kering hijauan dan konsentrat adalah 50:50% dengan total konsumsi bahan kering 3% dari bobot hidup sapi. Produksi total VFA dipengaruhi oleh bangsa dan bobot badan sapi, tetapi produksi N-NH_3 tidak dipengaruhi oleh bangsa, bobot hidup maupun taraf subsitusi. Rataan VFA (122.92±3.22 mM/l) dan N-NH_3 (4.14 ± 0.4 mM/l) masih dalam kisaran optimum untuk aktivitas mikroorganisme rumen. Analisis regresi menunjukkan bahwa koefisien cerna serat kasar mempunyai pola yang sama dengan produksi asetat, propionate, butirat dan valerat. Kesimpulannya kompos jamur merang dapat menggantikan rumput gajah sampai dengan 75% dari bahan kering rumput untuk diberikan pada sapi jantan baik bangsa PO maupun PFH.

Kata kunci : kompos jamur merang, VFA, Nitrogen Ammonia

Introduction

Rice straw is important feedstuff for ruminants in Indonesia especially in Java Island. This feedstuff is however characterized by high content of indigestible fiber due to increased lignification of cellulose. Fermentable energy and nitrogen deficiency in crop by product such as rice straw coupled with low digestibility impair the ruminal functions, feed intake and ruminant productivity (Sarwar et al., 2004). Several efforts such as physical, chemical and biological treatments have been used to increase quality of rice straw through weakening and breaking lignocellulose bonds, thereby increasing feeding value of this crop residu (Khan et al., 2005). These treatments are not the perfect method due to the cost; it is therefore not suitable.

Besides as animal feed ingredients, rice straw is a viable media for mushroom growth called spent rice straw compost (SRSC). SRSC is an available by-product from edible mushroom production, which constitutes a potential pollutant and is cost-effective for disposal (Fazaeli and Masoodi. 2006). In Asian countries, the fresh substrates of SRSC normally contains straw, poultry litter, urea, and limestone piled up outside for 15-25 days The substrates are then transferred to the growing bed, after which they are sterilized, fermented, and inoculated with the seed culture (Kim et al., 2011)

After growing and cropping of mushrooms more than two tons of spent rice straw (SCRS) remains from each ton of mushroom harvested (Oei, 1991). In Indonesia, around 150.000 kg SCRS were produced each day. About 5 kg of SCRS is produced for each kg of mushrooms (Williams et al., 2001). This mass of SCRS will become an increasing problem and disposal of the large volumes of material produced on a sizeable farm that present considerable environmental concerns of nitrate leaching into ground water to filling up landfills (Kleny and Wetzler, 1981). The compost is made by mixing rice straw, animal manure, calcium and nitrogen supplements (Bakshi and Langar, 1991; Valmaseda et al., 1991; Riahi et al., 1998). This waste material could be rich in microorganisms and extra-cellular enzymes (Ball and Jackson, 1995) and contains relatively high levels of nitrogen, potassium, phosphorus, calcium and trace elements, notably iron and silicon, (Langar et al., 1980; Burton et al., 1994) that may be used as animal feed. Inclusion of spent compost straw up to 20% of the diet do not affect the digestibility of DM, OM, CF, ADF and NDF, but the diet containing 30% compost straw had lower digestibilities. Nitrogen balance was also significantly different between the treatments (Fazaeli and Masoodi. 2006). Langgar et al. (1982) reported that spent *Agaricus bisporus* compost could be used as source of minerals for animals, as they are rich in major and trace minerals. However, Baksshi and Langgar (1991) reported that spent *Agaricus bisporus* compost had limited use as animal feed due to their high crude ash content (380–530 g/kg).

This study aimed to determine the level of replacement of fresh King grass with SRSC on rumen metabolism products. In addition to this objective was also to find out how much SRSC can replace the King Grass, without causing interference rumen metabolisms. This research was expected to provide benefits to various parties, among others: (1) assist farmers in solving the problem of lack of fresh forage for ruminants, particularly cattle, and (2) explore the available natural resources to use as fodder.

Materials and Methods

The research used Randomized Block Design with factorial of 2x4. Two kinds of cattle breeds namely factors I were 8 head of indigenous cattle (Ongole Crossbred = OC) with avarage body weight of 78.48 ± 7.69 kg and 8 heads of Fries Holland Cross Breed (FHC) of 83.93 ± 17,67 kg around eight to ten month old. They were kept in individual metabolism cages of 1 x 1.2 m and given four kinds of diets as factor II. There were four levels of King Grass substituted with SRSC of 0, 25, 50 and 75% of forage dry matter or 0, 12.5, 25, and 37.5% of dry matter (DM) total of diets. The compositions of the feedstuff and experiment diets are presented in Table 1. Dry matters intake (DMI) of individual cattle was fed according to NRC (1984) with DM ratio of forage and concentrate were 50:50% (Table 2). The research was conducted in Experimental Farm of Animal Science Faculty, Jenderal Soedirman University, Purwokerto.

Diets were offered four times a day at 07.00, 09.00, 14.00 and 17.00. Concentrates were offered at 07.00 and 14.00, while napier grass and SRSC according to the treatments were

Table 1. Nutrient Composition of Feedstuff and Diets of Experimental

	Feedstuff			Diets			
	FNG	SRSC	Cons.	R_0	R_1	R_2	R_3
DM (%)	11.67	76.34	86.16	-	-	-	-
CP (% DM)	8.62	7.98	14.62	10.81	10.55	10.32	10.11
CF (% DM)	30.74	15.50	6.50	13.8	12.64	12.53	10.52
EE (% DM)	2.61	1.81	12.79	7.80	7.40	7.05	6.72
NFE (% DM)	-	-	-	51.96	52.54	52.63	53.51
Ash (% DM)	19.30	29.35	16.70	15.54	16.87	18.06	19.14
Ca (% DM)	0.12	0.76	0.21	0.16	0.23	0.30	0.36
P (% DM)	0.28	0.19	0.75	0.50	0.48	0.45	0.45
TDN (% DM)	-	-	-	58.74	54.74	56.46	53.34
GE (Mkal/kg DM)	4.280	3.709	4.544	-	-	-	-

DM = dry matter; CP = crude protein ; CF = crude fiber; NFE =nitrogen free extract; Ca = calsium; P = posphor; TDN = total digestible nutrient; GE = gross energy; FNG = fresh napier grass segar; Cons. = consentrate
R_0 : Napier Grass substituted with Spent rice straw compost (SRSC) 0%; R_1 : Napier Grass substituted with SRSC 25%; R_2 : Napier Grass substituted with SRSC 50%;, R_3 : Napier Grass substituted with SRSC 75%

Tabel 2. The Composition of Experimental Diets

Feedstuff	Experimental Diets (% DM)			
	R_0	R_1	R_2	R_3
Consentrate	50	50	50	50
Fresh Napier Grass (FNG)	50	37.5	25	12.5
SRSC	0	12.5	25	37.5

R_0 : Napier Grass substituted with Spent rice straw compost (SRSC) 0%; R_1 : Napier Grass substituted with SRSC 25%; R_2 : Napier Grass substituted with SRSC 50%;, R_3 : Napier Grass substituted with SRSC 75%

offered at 09.00 and 17.00. Drinking water was supplied ad libitum.

The time needed for this experiment was 56 days for adaptation, 14 days for preliminary and 7 days for collection. During the collection, the animals were fitted with harnesses to ensure separation of urine and faeces. Feed offered and refused were weighed and recorded daily to calculate nutrients composition.

Total faeces was collected at 07.00 every day of the collection period. During the periods collection sample representing 5% of the total weight were dried in oven at 85^0C over-night and stored for analysis. Napier grass and SRSC were cor-sampled and concentrates were grap-sampled and composited for each treatment for analysis of chemical composition (Lewis et al., 1996). Napier grass, SRSC and concentrates samples were ground to pass a 1 mm-screen for determination of DM, CP, EE, CF and Ash (AOAC. 1990).

Rumen fluid was taken at 07.00 before feeding at day 7 of collection periods. After collection, rumen fluid was separated for ammonia and VFA analysis by centrifuging at 5000 rpm for 10 minutes. The supernatant fraction was decanted and kept frozen -20^0 C until being analysed for N-NH_3 and VFA. Production of N-NH_3 in the rumen was analysed by using Micro diffusi Conway Technique (Sutardi, 1979). Ruminal individual VFA was measured by gas chromatography according to Krause et al. (1998).

Data were analysed by analysis of covariance according to general linear model procedure of the statistical analysis system using model suitable Randomized Block Design (RBD). Orthogonal polynomial test was used to

find the respond of the treatment (Steel and Torrie, 1981).

Results and Dicussion

Volatile Fatty Acid Production

Various factors such as consumption of dry matter, chemical composition of diets, diet physical form and condition of animal physiology, will interact and determine the pattern of fermentation in the rumen, which in turn determine the VFA products and N-NH3 product (Sullivan et al., 2005; Thomas and Rook, 1981; Suwandyastuti, 2007). Total production of volatile fatty acids (VFA) and its individual composition in the rumen are the indication of the presence or absence of glucogenic or ketogenic compounds also the indicator of the amount and rate of fermentation. Variance analysis showed that there were no interactions of SCRS and cattle breed on total VFA production. However, total VFA production was influenced by the breed of cattle and the body weight ($P<0.05$).

The VFA production of Frisien Holstein Crossbreed (FHC) cattle group was higher than that of Ongole Crossbreed (OC) group (Table 3). This suggested that the physiological condition of animals still influenced the total VFA production. Total VFA production cattle of FHC was higher than local cattle OC, probably because rumen and microbes development were more optimal in cattle of PFH, it could therefore produce more VFA. Total VFA production was still within the normal range (122.92 ± 3.22) mM/1. This indicated that utilisation of SCRS did not interfere rumen microbial activity. Park et al. (2012) reported that utilization of spent mushroom subtrates in the diet of Elk can increase the Hgb, serum BUN, glucosa and HDL-cholesterol concentration.

Carbohydrates breakdown in the rumen occured in two stages: (1) the carbohydrates breakdown into glucose and (2) glucose breakdown into pyruvate, which was then converted into VFA. Each type of carbohydrate

Table 3. The Average of VFA Production at Various Treatment Combination

Breed of Cattle	Treatment Diets			
	R_0	R_1	R_2	R_3
B 1				
Total VFA (mM/1)	130.86	137.96	125.30	127.71
Relative Proportion (%)				
Acetate (C_2)	54.29	57.47	52.99	49.67
Propionate (C_3)	24.57	24.01	26.27	26.64
Butyrate (C_4)	13.78	12.51	13.90	17.69
Isobutyrate (iC_4)	2.55	1.96	2.41	1.86
Valerate (nC_5)	2.07	1.72	1.84	2.14
Isovalerate (iC_5)	2.74	2.33	2.59	2.00
B 2				
Total VFA (mM/1)	110.46	117.90	117.86	115.30
Relative Proportion (%)				
Acetate (C_2)	54.63	53.89	49.27	53.52
Propionate (C_3)	23.82	21.89	29.26	19.76
Butyrate (C_4)	14.50	15.60	15.49	14.45
Isobutyrate (iC_4)	2.65	2.94	2.13	3.13
Valerate (nC_5)	1.02	1.51	1.29	15.54
Isovalerate (iC_5)	3.38	4.19	2.56	3.60

B1= Frisien Holstein Crossbreed (FHC); B2 = Indigenous Cattle = Ongole Crossbreed (OC); R_0 : Napier Grass substituted with Spent rice straw compost (SRSC) 0%; R_1 : Napier Grass substituted with SRSC 25%; R_2 : Napier Grass substituted with SRSC 50%;, R_3 : Napier Grass substituted with SRSC 75%

produced a specific product of rumen fermentation. If the crude fiber digestibility in the rumen was high, the resulting fermentation product mostly composed of acetate. Conversely, if the glucogenic fermentation compounds occupied a higher proportion, the main fermentation product consistedof propionic acid (Mc Donald et al., 2002).

Volatile fatty acids are the main energy source for ruminants that are mostly absorbed in the rumen, immediately after the carbohydrate fermentation process takes place. In addition, some essential fatty acids, especially the branches chain, such as valerate and fumarate are used by rumen microbes as a carbon source for microbial protein synthesis and for energy sources in the synthesis process. Therefore, VFA measurement in the rumen did not perfectly reflect the results of the fermentation process, but rather as a product of rumen metabolism. The process of fermentation, synthesis and absorption in the rumen always occurred simultaneously, resulting in difficult proper separation of each process. It might also lead to the ever diverse and fluctuative production of volatile fatty acids (Philipson, 1970; Cole and Ronning, 1974).

The fermentation process has always interacted and it has covered relationship with population, the type and rumen microbial activity. Digestion of feed and digesta components can only take place in an optimal, provided that the type, amount and activity of microbes are also optimal. Rumen microbes can grow and develop and play an active role in the metabolic process, if the availability of nutrients and raw material (precursor) in a state of balanced and adequate (Satter and Slyter, 1974).

Experimental diets containing crude fiber from 10:52 to 13:18% at ratio of forage:concentrate of 50: 50%. DM and increased SCRS enhanced crude fiber digestibility ($P<0.01$). The interaction between the cattle breed and levels of subsititution on the digestibility of crude fiber had quadratically shown a positive effect ($P<0.01$). Results of statistical analysis showed a relationship between the digestibility of crude fiber, C_2 and the level of substitution of King grass as followed: (1) in group cattle of OC, the minimum digestibility of crude fiber achieved at 20.83% substitution level while C_2 reached a maximum rate of 11.5% substitution, (2) in cattle PO, maximum crude fiber digestibility reached 18:41% substitution level, while the maximum C_2 was achieved at 22:32% substitution level. This result illustrated that not all results of crude fiber digestion was used for the formation of C_2, but there were other products unmeasured in this study. Bryant (1970) stated that most of the rumen acetate may be produced through pyruvate with two common reactions namely: (1) oxidative decarboxylation which produces acetate, CO_2 and H_2, and (2) phosphorylation (phosphorus solution) or a reaction that produces both acetic and format. CO_2 formed is reduced with H_2 to form CH_4. Sutardi (1977) stated that biofermentasi system in rumen anaerobic is inefficient because most of the energy will be wasted as heat and methane gas. Those products not measured in this study were CH_4, CO_2, H_2, and format the heat of fermentation.

Although frequently disregarded in estimating the efficiency of energy use, butyrate acid had similar characteristic with acetate (ketogenic), therefore the molar amount of butyrate was subject to account. When the molar amount of C_3 namely glucogenic can not offset the amount of acetate and butyrate molar namely ketogenic, it is necessary to attempt manipulation of rumen fermentation products in order to achieve optimal efficiency of energy use. The results of these experiments showed that relatively small amounts of butyrate molar were only 14:47 ± 1:12% of VFA at FHC and 15:01 ± 0:31% VFA at OC cattle. In contrast to C_2, C_3 and C_4, branch-chain fatty acids such as isobutirat, valerate,

and isovalerat required less attention because of the insignifficant amount. These fatty acids however played an important role in the process of rumen metabolism, as the source of carbon skeleton for microbial protein synthesis

In Table 4 it was obvious that each of the volatile fatty acid molar had the same form of relations pattern with the crude fiber digestibility of the experiment diets. All of equations were cubic line shape (Table 4), although the magnitude of the coefficient of determination and the relationship was different. The results of this experiment were different from previous theoretical and experimental results (Sutton, 1980; Suwandyastuti, 2007) where the molar amount of acetic acid production had close relationship with the level of crude fiber digestibility of the ration (R^2 = 75.6%, P<0.01), whereas the relationship with the production or the amount of propionate molar appears to remain normal.

The above results illustrated that not all products in the rumen digestion of crude fiber was used for the synthesis of C_2, but there were other synthetic products that were not measured in this experiment. On the other hand, not all C_2 fermentative digestion products derived from crude fiber in the rumen.

Nitrogen Amonia Product

In contrast to carbohydrates, only 30% from protein feeds had fermentative digestion in rumen, while the remaining 70% were digested enzymatically in abomasum, as occured in monogastric animals. However, the products of protein fermentation in the rumen are an important factor to note. As with carbohydrates, protein in the rumen also underwent some stages of the degradation. The first protein phase would be broken down into amino acids, but most of rumen microbes (approximately 82%) could only use ammonia nitrogen (NH_3-N) as nitrogen source for the synthesis of body protein, the amino acid immediately degraded further into N-NH_3 (Sutardi, 1977). Average productions of N-NH_3 from each treatment were presented in Table 5. Production of N-NH_3 in the groups of FHC of 4:07 ± 0.2 mM/1 and 4:22 ± 0:09 mM/l for OC cattle, which was still within the optimal for rumen microbs activities. This suggested that SCRS was used as an energy source for protein synthesis or optimal rumen microbial growth.

Covariance analyses showed that production of N-NH 3 were not influenced by weight group, the treatment and the interactions (P>0.05). Although the results were not significant, the average production of N-NH 3 from cattle fed on R3 was better than the other three rations fed to the FHC, although both could support the growth of rumen microbes. It was because the cattle fed on R3 had lower N-NH3 production indicating that protein content of SCRS was more resistant to degradation by rumen microbes, so more proteins passed to the abomasum if compared to the other three rations.

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Table 4. The Relationship Between Rumen Metabolism Product (Y) with Crude Fiber Digestibility (X)

Variable	Equations	R^2 (%)
C_2	$Y= 954.8 + 43.9X - 0.7X^2 + 0.03X^3$	75.6
C_3	$Y= -409.1 + 18.6X - 0.3X^2 + 0.015X^3$	29.2
C_4	$Y= -177.8 + 54.3X - 0.8X^2 + 0.04X^3$	44.6
iC_4	$Y= -30.7 + 14.1X - 0.21X^2 + 0.001X^3$	38.5
iC_5	$Y= -84.3 + 17.3X - 2.6X^2 + 0.013X^3$	61.4
iC_5	$Y= -71.6 + 49.3X - 7.5X^2 + 0.037X^3$	51.8

Table 5. Average Nitrogen Amonia ($N\text{-}NH_3$) production at Various Treatments Combinations

Breed of Cattle	Experimental Diets (mM/l)			
	R_0	R_1	R_2	R_3
B_1	4.64 ± 0.41	4.07 ± 0.38	3.80 ± 0.76	3.78 ± 0.03
B_2	4.35 ± 0.77	4.39 ± 0.71	4.07 ± 0.40	4.08 ± 0.39

B_1= Frisien Holstein Crossbreed (FHC); B_2 = Indigenous Cattle = Ongole Crossbreed (OC); R_0 : Napier Grass substituted with Spent rice straw compost (SRSC) 0%; R_1 : Napier Grass substituted with SRSC 25%; R_2 : Napier Grass substituted with SRSC 50%;, R_3 : Napier Grass substituted with SRSC 75%

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Conclusions

Based on all the observed and measured response variables, it can be concluded that digestibility crude fibers had the same pattern of relationships with C_2, C_3, C_4 and C_5. The spent compost rice straw (SRSC) could substitute Napier grass to fed male cattle up to 75 percent of forage DM.

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