The Performance of Bali Cattle Fed Ration Containing *Pleurotus osteorus* Fermented and Urea-Ammoniated Sago Waste

I. Sangadji [1], A. Parakkasi [2], K.G. Wiryawan [2], B. Haryanto[3]
[1)] Department of Animal Science, Faculty of Agriculture, Pattimura University, Ambon
[2)] Nutrition and Feed Technology Department, Faculty of Animal Science, Bogor Agricultural University, Bogor
[3)] Indonesian Research Institute for Animal Production, Bogor

ABSTRACT

Sago waste is an agricultural by product with low nutritive value. The present experiment was designed to study the effects of using treated sago meal to substitute grasses on Bali cattle productivity. Fifteen young male Bali cattle, approximately 18-month of age were allocated to experimental treatments according to the average weight of the animal in a randomized complete block design. Native grass was used in the experiment. The dietary treatments were (1) 60% grasses and 40% concentrate, as control, (2) substituting 15% of grasses with fermented sago waste, (3) substituting 30% of grasses with fermented sago waste, (4) substituting 15% of grasses with ammoniated sago waste, and (5) substituting 30% of grasses with ammoniated sago waste. The results showed that substituting 50% of the grass with treated sago waste gave the greatest daily weight gain (0.66kg) as compared to the other treatments ($P<0.05$). Intake and digestibility of feed dry matter, organic matter and fiber components were not significantly different among treatments. However, the digestibility of ADF and cellulose were greater when 15% and 30% of the grass were substituted with fermented sago waste. The feed to gain ratio was most efficient in the animal receiving 50% bio-processed sago waste as substitute of native grass. The rumen characteristics showed that concentration of NH_3 and VFAs were not significantly different among treatments. It was concluded that bio-fermentation of sago waste using *Pleurotus ostreatus* and ammoniation with urea improved its nutritive value and could be used to substitute native grass for cattle.

Key words: sago waste, biofermentation, Pleurotus ostreatus, ammoniation, beef cattle

INTRODUCTION

Lately, the demand of beef in Indonesia increase rapidly, therefore efforts to accelerate the beef production should be done. Bali cattle an alternative breed to be developed to fill the gap between the supply and demand of meat. Beef consumption increased from 330,300 ton in the year 2002 to 389,300 ton in 2006. Unless an appropriate move in accelerating beef production being taken, the beef cattle population will decrease significantly. Fortunately, the cattle population trend to increase from 10,532,889 in 2004 to 11,869,158 in 2008 (DITJENAK, 2008).

The primary constraint to cattle is productivity that the requirement of nutrient for a better production is not satisfied by the existing feed condition, especially protein so that the livestock do not perform their maximum genetic capacity. The grasses in tropical countries are mostly of low quality and usually fed to the animal at mature stage in which advanced lignifications of the structural polysaccharide components have developed. Meanwhile, planting superior grasses such as elephant grass and guinea grass have a constraint of limited area.

Utilization of by products of agro industries, such as sago waste is one alternative to overcome this problem. However, it is realized that the utilization of the sago waste need preliminary treatment due to the high in fiber and low in protein content. Toharmat (2002) stated that feed with high fiber content will be slowly digested in the rumen and ends approximately after 72 hours inside the rumen.

Biological processing of sago waste that has been done was bio-fermentation using oyster mushroom. This mushroom is grouped in class of *basidiomycetes* which could be cultivated on different kinds of agricultural wastes and could also be consumed by human being. Rai and Saxena (1990) stated that cultivation is not only cheap, but also able to improve the quality of feed. Okano *el al.* (2005) stated that the fermentation of *Japanese red cedar* with white rot *basidiomycetes* (oyster mushroom) could increase the dry matter digestibility. Ammonia treatment could also to increase the quality of feed where the processing technology with urea will increase the crude protein content (Broudiscou *et al*., 2003). The *in vitro* nutrient digestibility of amoniated rice straw resulted from ammoniation was higher than rice straw which was not ammoniated (Eun *et al*., 2006). Based on these informations, the sago waste which has been processed through fermentation with oyster mushroom and ammoniation with urea was tried to feed to cattle replacing native grasses.

The objective of the present experiment was to study the influence of sago waste based ration on the digestibility and fermentability of feed and the productive performance of Bali cattle. It is hoped that the sago waste can be used as feedstuff to substitute the grasses during the dry season, in addition to preventing the environmental pollution especially in the area of sago powder producer.

Table 1. Ingredient composition and nutrient content of rations

	Treatment of ration				
Component of ration	R0	R1	R2	R3	R4
	……………………….%......................................				
Ingredient					
Native grass	60	45	30	45	30
Fermented-sago waste [a)]	0	15	30	0	0
Ammoniated-sago waste	0	0	0	15	30
Concentrate	40	40	40	40	40
Total	100	100	100	100	100
Nutrient composition	...…………………......%.....................................				
Proximate Analysis[*)]					
Dry matter	88.1	88.3	88.4	88.1	87.9
Crude protein	12.8	12.1	11.5	12.2	11.6
Fat	4.6	4.5	4.4	4.5	4.4
Crude fiber	27.4	23.5	19.6	24.2	20.9
Ash	8.6	9.3	9.9	8.7	8.7
NFE	46.6	50.6	54.6	50.5	54.4
Goering &Van Soest Analysis [**)]					
NDF	43.9	42.8	41.8	44.4	44.9
ADF	30.4	29.3	28.1	31.2	31.9
Cellulose	22.4	21.2	20.0	22.5	22.6
Lignin	4.2	4.1	4.0	4.6	4.9
Silica	1.4	2.2	2.9	2.3	3.3
TDN[***)]	51.3	55.9	59.2	55.0	58.7

Note: NFE = Nitrogen free extract; NDF = *Neutral Detergent fiber*; ADF = *Acid detergent fiber*; TDN= *Total Digestible Nutrients* [*)] Analysis of Animal Biology Laboratorium; [**)] Indonesian Research Inst. Animal Production, Ciawi-Bogor; [***)] Calculated; [a)] Fermented sago waste from field for biological test, fermented for 50-60 days.

Table 2. The average of dry matter, organic matter consumption, body weight, body weight gain and rations conversion

Items	Treatment of rations				
	R0	R1	R2	R3	R4
Consumption					
Dry matter (% BW)	$2.58{\pm}0.1^{a}$	$2.69{\pm}0.3^{ab}$	$3.06{\pm}0.1^{c}$	$2.67{\pm}0.1^{ab}$	$2.85{\pm}0.3^{bc}$
Organic matter (%BW)	$2.42{\pm}0.1^{a}$	$2.45{\pm}0.0^{a}$	$2.68{\pm}0.1^{b}$	$2.44{\pm}0.0^{a}$	$2.64{\pm}0.1^{b}$
Body weight					
Initial (kg/head)	142±2.0	133±2.3	132±2.1	136±2.0	124±2.5
Final (kg/head)	17±1.8	162±5.1	171±2.0	163±4.7	161±3.6
Total gain (kg/head)	29.2±1.8	29.7±5.1	39.3±1.5	27.3±3.5	36.7±5.1
Daily gain (kg/head/day)	$0.48{\pm}0.1^{ab}$	$0.49{\pm}0.1^{ab}$	$0.65{\pm}0.1^{c}$	$0.45{\pm}0.1^{a}$	$0.61{\pm}0.1^{bc}$
Ration conversion	$7.96{\pm}0.4^{b}$	$7.47{\pm}1.4^{ab}$	$5.96{\pm}0.3^{a}$	$8.05{\pm}0.9^{b}$	$6.07{\pm}1.1^{a}$

Note: [a,b,c]Within rows, means followed by different superscript differ (P<0.05);R0=control ration; R1= 45% grass + 15% fermented sago waste + 40% concentrate; R2=30% grass + 30% fermented sago waste + 40% concentrate; R3= 45% grass + 15% ammoniated sago waste + 40% concentrate; R4= 30% grass + 30% ammoniated sago waste + 40% concentrate; BW= body weight.

MATERIALS AND METHODS

The experiment was carried out in a randomized block design, with 5 treatments and 3 groups of cattle based on body weight. The differences between the treatment means were analyzed using Duncan test (Steel and Torrie 1991). The treatments were as follows:

R0 = 60% native grass + 40% concentrate

R1 = 45% native grass + 15% fermented sago waste + 40% concentrate

R2 = 30% native grass + 30% fermented sago waste + 40% concentrate

R3 = 45% native grass + 15% ammoniated sago waste + 40% concentrate

R4 = 30% native grass + 30% ammoniated sago waste + 40% concentrate

RESULTS AND DISCUSSION

Feed Intake, Body Weight Gain and Feed Conversion

Intake of dry matter ranges between 2.58-3.06% of body weight. These results are higher than those observed by Anggraeny and Umiyasih (2004) in beef cattle which were 2.0-2.1%. Cattle receiving rations containing fermented sago waste at 30% (R2) consumed higher ($P<0.05$) feed compared to cattle fed with R0, R1 and R3 but there was not different from R4 (Table 2).

Average intake of organic matter by cattle receiving R2 treatment was higher ($P<0.05$) than the cattle at R0; however the organic matter intake of cattle at R1 and R3 were equal to R4. The lack of difference in intake of dry matter and organic matter between R2 and R4 treatment showed that the use of fermented sago waste or ammoniated sago waste to replace 50% grass in the ration did not bother the palatability and other factors which affect consumption. This may be caused by physical and chemical properties of processed sago waste which resulted in a better quality so that it is preferred by the animal. Parakkasi (1995) stated that such factors influencing the consumption of feed materials include physical and chemical properties of the feed.

The product of fermentation has a higher nutritional value than the original material because the microbes have degraded the more complex material into simpler substances, making them easier to digest. Fermentation process will also cause changes in chemical composition such as fat, carbohydrates, amino acids, minerals and vitamins as a result of the activities and proliferation of microorganisms during the fermentation procress (Winarno, 1992). The use of fermentation in the sago waste tends to increase the rations NFE, lower crude fiber, NDF, ADF, cellulose, hemicellulose and lignin thereby increasing the ration consumption.

Ammonia treatment can increase the consumption of dry matter and organic matter (Weiss and Underwood, 2002). The increased consumption due to the ammonia treatment was related to the damage of the chemical bonds between the lignin and the cellulose or hemicellulose. The fact that lignin inhibits fiber digestion therefore damaging the bond causes hemicellulose and cellulose to be more digestible. The high cosumption of dry matter and organic matter can also be affected by the treatment of fermentation and ammoniation by creating a more conducive environment of rumen conditions for microbial activity which is indicated by the normal range of total VFAs. These conditions encourage the growth of microbes and the movement of food in the digestive tract become aroused quickly and animal to consume more. Leng (1991) suggested that the level of consumption is strongly influenced by the coefficient of indigestion, the quality of rations, fermentation in the rumen and the physiological status of animal.

Beef cattle production which is reflected in the increase of body weight is the main goal in testing a ration, where the change in body weight is the result of such treatment. "Body weight gain" of cattle receiving dietary treatments in the present experiment ranged from 0.456 - 0.655 kg/head/day. These values were higher than the results of experiment reported by Mathius *et al*. (2005), using Bali cattle fed with palm kernel meal fermentation, which increase body weight gain ranging from 0.310 - 0.582 kg/head/day. The increased body weight was significantly different between cattle treated with R2 ($P<0.05$) as compared to R0, R1 and R3 but not different from R4, and R0 was not different from R1 and R3. The higher body weight gain in cattle fed rations containing 30% fermented and ammoniated sago waste, showed that there was a positive response of the cattle to the rations. Body weight gain is the accumulative response of animal to the feed intake, digested nutrients, fermentation, metabolism and absorption of nutrients. The higher increase in the body weight of cattle fed with 30% treated sago waste was caused by higher consumption of dry matter and organic matter.

The lowest "Feed Conversion ratio" (FCR) was observed in cattle receiving fermented sago waste at 30% (R2) i.e., 5.96 and the highest was for the cattle treated at 15% ammoniated sago waste i.e., 8.05. Research conducted by Adamovic *et al*. (1998) for beef cattle fed rice straw biodegraded by oyster mushrooms showed higher FCR, i.e., 7.41 - 9.14. Table 2. shows that the feed conversion ratio of cattle fed R2 was significantly lower (P<0.05) as compared to R0 and R3, but equal to R1 and R4.

The results showed that the substitution of grass by the fermented and ammoniated sago waste until 50% tended to improve the feed conversion ratio significantly. These were indicated by the higher body weight gain in R2 and R4 than those in R0, R1 and R3. This proves that the treatment using product fermentation and ammoniation of sago waste at 30% were able to improve the changes of feed dry matter into live body weight , which for the formation of 1 kg of live weight only 5.96 and 6.07 kg feed dry matter were needed.

"Analysis of the cattle business income" is necessary to know the advantages of a livestock business. Income over Feed Cost (IOFC) as illustrated in Table 3 is a simple economic analysis used to see the benefits of beef cattle business. The income over feed cost is influenced by the amount of feed consumption, prices of feed ingredients and the amount of the daily weight increase produced. Income over Feed Cost of cattle in R2 was substantially higher (P<0.01) compared to R3 and substantially higher (P<0.05) from R0, R1, R4, while R0 equal to R1, R3 and R4.

IOFC difference is due to the additional cost of the oyster mushroom fermented sago waste. Income over Feed Cost was higher with increasing use of fermentation in the sago waste in the rations. This shows that the rations containing fermented sago waste is more efficient and profitable. The use of ammoniated sago waste will provide greater benefits than cattle fed the control treatment when used up to 30% in the ration (Table 3).

Nutrient Digestibility

The ration digestibility was influenced by feed intake, nutrient content and digesting process in the rumen and the post-rumen compartment (Beever and Mould, 2000). Dry matter, organic matter, protein and NDF digestibility of Bali cattle were not influenced by ration type. Results of this experiment showed that the use of processed sago waste for feeding Bali cattle to substitute the grass gave the same effect with the control (R0). The fiber source of R0 treatment was native grass with good quality which was comparable to sago waste. Based on the data, of Table 4, there is an indication that fermentation and ammoniation treatment could be applied to increase the quality of sago waste resulting in similar digestion responses.

Dissolution of crystalline cellulose-lignin bonds (in the form of an ester bond) with koniferil, sinapil and *p*-kumaril alcohol in fermentation treatment facilitate the penetration of cellulases produced by rumen microbes. Dissolution of the bond was marked by increasing the solubility of each fibrous component (hemicellulose, cellulose, lignin). This decreases the percentage content of fiber components so that *in vivo* digestion of feed fiber components increased (Maynard *et al*., 1980).

The average digestibility of dry matter in this study is higher than studies conducted by Li *et al*. (2001) in cattle using cotton seed hull fermented by oyster mushroom which was 52.3%. An experiment conducted by Prasetiyono *et al*. (2007) in beef cattle fed rice straw with the addition of CASREA (Cassava urea) also showed a lower result, i.e., 50.42%.

Table 3. IOFC (Income Based on Value of Body Weight Gain)

Items	Treatment of rations				
	R0	R1	R2	R3	R4
Feed cost (Rp/head/day)	5,759.7	7,377.5	10,133.4	5,779.7	6,099.0
Value of BW (Rp/head/day)	10,685.7	10,057.1	14,457.1	9,219.0	13,409.5
Value of mush. (Rp/head/day)	0.0	4,033.2	8,738.6	0.0	0.0
IOFC (Rp/head/day)	4,926.1[ab]	6,712.8[ab]	13,062.4[c]	3,439.4[a]	7,310.6[b]

Note:[a,b,c]Within rows, means followed by different superscript differ (P<0.05);R0=control ration; R1= 45% grass + 15% fermented sago waste + 40% concentrate; R2=30% grass + 30% fermented sago waste + 40% concentrate; R3= 45% grass + 15% ammoniated sago waste + 40% concentrate; R4= 30% grass + 30% ammoniated sago waste + 40% concentrate; BW= body weight; mush= mushroom; IOFC= income over feed cost.

There were significantly different ADF digestibilities between treatments. The use of ammoniated sago waste at 30% in the ration resulted in the same effect on ADF digestibility as in control, but decreased significantly as compared to the use of ammoniated sago waste at 15%, and fermented sago waste at 15% and 30%. This difference is probably due to the ADF content of the rations. Table 1 shows that the level of ADF tended to increase with increasing use of ammoniated sago waste in rations (0.8 - 1.5%).

Digestibilities of nutrients in all treatments were greater than 50% (Table 4.) indicating that the ration treatment and the condition of the cattle rumen bacteria support an optimal activity. One way to measure the rumen microbial activity is the value of nutrients in digested ration components. Increased rumen microbial activity was stimulated by the availability of ammonia and VFA in the rumen, where the concentrations of these two compounds are in the normal range to support the growth and rumen microbial activity.

Characteristics of Rumen and the Microbial Fermentation

Ammonia

The results showed that the characteristics of microbial fermentation in the rumen were not affected by treatment (Table 5). No differences between the treatments on ammonia concentrations showed that all treatments provide similar level of ammonia into the rumen, although the type of bacteria that use ammonia are different.

The main product of protein degradation by rumen microbes is ammonia, which most of the microbes use it for *de novo* protein synthesis. Therefore, the ability to provide sufficient ammonia in the rumen is often used as a benchmark in the evaluation of feed protein for ruminant livestock. Ammonia levels ranged from 10.10-13.67 mM (Table 5.), and the highest values obtained in R4. Preston and Leng (1987) stated that the concentrations of ammonia in the rumen for optimal microbial growth were 4 - 14 mM. The results of this study showed that fermentation technology and ammoniation of sago waste were still able to ensure adequate supply of ammonia in the rumen.

Volatile Fatty Acids (VFAs)

Carbohydrates are fermented in the rumen by microbes into fatty acids or VFAs. VFAs will be absorbed and used as source of energy for animal and a source of carbon skeleton for the bacteria. Concentration of volatile fatty acids in the fermentation media described the effectiveness of the fermentation process. In general, the higher concentration of VFA indicates fermentation process to be more effective; however, when the VFA concentration is too high, it will disrupt the balance of rumen microbial population.

Higher concentration of VFA in rumen fluid of cattle given R2 indicates that rumen bacterial growth in this treatment is better than the other treatments. These results indicate that overall carbohydrate rations degradation was higher in R2, although not significantly different. R2 ration containing fermented sago waste at 30% allows the easy availability of carbohydrates being degraded, because the fermentation process has disrupted the ligno-cellulose bonds causes fiber-degrading bacteria to work better.

Table 4. Average Nutrient digestibility of Bali cattle

Items	Treatment of rations				
	R0	R1	R2	R3	R4
	---------- % ----------				
Dry matter	76.5±0.1	70.1±4.9	72.6±0.7	74.4±0.7	72.6±2.5
Organic matter	73.4±2.6	69.5±3.8	70.3±6.6	72.4±1.1	71.7±1.7
Protein	79.8±2.3	75.4±7.8	75.3±0.7	79.5±1.0	75.7±3.8
NDF	58.9±1.1	55.1±7.8	56.7±0.9	59.1±2.3	58.5±2.7
ADF	54.4±6.1^{ab}	60.4±3.7^{b}	60.3±1.5^{b}	59.9±3.3^{b}	51.8±2.3^{a}
Cellulose	66.4±2.2	63.4± 9.8	67.9±10.4	69.5±2.8	58.3±1.2

Note: ^{a,b,c} Within rows, means followed by different superscript differ (P<0.05);R0=control ration; R1= 45% grass + 15% fermented sago waste + 40% concentrate; R2=30% grass + 30% fermented sago waste + 40% concentrate; R3= 45% grass + 15% ammoniated sago waste + 40% concentrate; R4= 30% grass + 30% ammoniated sago waste + 40% concentrate; NDF= Neutral detergent fiber; ADF= Acid detergent fiber.

Total VFA productions in this study were within the normal range of 106.8 - 144 mM (Table 5). The results of this study are not much different from what was obtained by Deborah *et al*. (2005) on the use of probiotics in the Bali cattle, i.e., 130.33 - 158.67 mM. Fermentability of feedstuff carbohydrate as measured from the VFA results are supported by the availability of sufficient ammonia in the rumen. Most of rumen microbes use ammonia to proliferate especially for cell protein synthesis (Suryahadi & Amrullah, 1984), whereas the origin of feed carbohydrates will be hydrolyzed to VFA as an energy source. This shows the relations between the two compounds (ammonia and VFA) in supporting optimum growth for the rumen microbes.

Partial VFA production was still fall within the normal proportions. This experiment produced higher proportion of acetic acid, i.e., 63.8-68.8%, followed by propionic acid 19.0-22.2%, butyric acid 9.4-10.9%, isobutiric acid 1.2-1.7%, valeric acid 0.0-0.5% and 1.1-1.7% isovaleric (Table 6). Nagaraja *et al*. (1997) concluded that the partial VFA production was influenced by the balance between roughage and concentrates in the ration, or the higher fiber content of the feeds will result in relatively higher proportions of acetic than propionic, and butyric. On the other hand, if concentrate portion was higher in the ration, then the proportion of propionic acid was higher.

Preston and Leng (1987) reported that VFA production in the rumen was influenced by various factors including: kind of animal, kind of feed, quantity and quality of feed. No differences in VFA concentrations between the treatments may also be due to similar feed quality between treatments. This study shows that the use of sago waste, after being fermented or ammoniated, in the ration did not affect rumen characteristics. This means that the residue of sago waste processing can be used up to 30% in cattle rations, because they do not significantly interfere the rumen microbial activity.

Table 5. The average of ammonia concentration, VFA total and partial of Bali cattle rumen fluid

Items	Treatment of rations				
	R0	R1	R2	R3	R4
	..........mM..........				
Ammonia	12.2±2.7	10.1± 1.9	11.0±2.1	11.3±3.6	13.7±2.1
Total VFA	114±5.0	120.3±10.0	144±9.4	106.8±27.8	113.2±31
Acetic acid	93.4±3.1	74.4±7.1	82.9±7.8	68.5±16.9	71.4±17
Propionic acid	30.4±3.3	23.8±2.7	22.8±2.1	22.7±6.1	25.6±9.9
Butyric acid	15.8±2.3	12.8±2.3	11.3±0.5	11.5±3.3	11.5±4.4
Isobutyric acid	1.8±0.2	1.3±1.5	1.8±0.6	1.6±0.6	2.6±1.2
Valeric acid	0.5±0.4	0.5±0.4	0.2±0.3	0.6±0.7	0±0.0
Isovaleric acid	2.2±0.4	1.8±0.4	1.3±0.1	1.9± 1.1	2.0±1.0

Note: R0=control ration; R1= 45% grass + 15% fermented sago waste + 40% concentrate; R2=30% grass + 30% fermented sago waste + 40% concentrate; R3= 45% grass + 15% ammoniated sago waste + 40% concentrate; R4= 30% grass + 30% ammoniated sago waste + 40% concentrate; VFA= volatile fatty acid.

Table 6. The average of VFA proportion in rumen fluid of Bali cattle

Items	Treatment of rations				
	R0	R1	R2	R3	R4
	..........mM..........				
Acetic acid	64.8±3.1	65.3±2.4	68.8±1.2	64.2±0.9	63.8±5.6
Propionic acid	21.1±1.7	20.9±2.2	19.0±0.4	21.2±1.4	22.2±3.4
Butyric acid	10.9±1.6	11.2±1.1	9.4±0.5	10.8±2.2	10.0±1.3
Isobutyric acid	1.2±0.2	1.2±0.1	1.5±0.7	1.5±0.3	1.7±0.3
Valeric acid	0.3±0.3	0.4±0.3	0.2±0.3	0.5±0.5	0±0.0
Isovaleric acid	1.6±0.3	1.1±0.2	1.1±0.1	1.7±1.5	1.7±0.4

Note: R0=control ration; R1= 45% grass + 15% fermented sago waste + 40% concentrate; R2=30% grass + 30% fermented sago waste + 40% concentrate; R3= 45% grass + 15% ammoniated sago waste + 40% concentrate; R4= 30% grass + 30% ammoniated sago waste + 40% concentrate.

CONCLUSIONS

Sago waste, after being fermented or ammoniated can be used until 30% in the rations or substituting 50% of grass and significantly increased the dry matter and organic matter intake, body weight gain and feed conversion ratio, but did not influence the nutrient digestibility and rumen characteristic of Bali cattle.

REFERENCES

Adamovic MG, Grubic, Milenkovic I, Jovanovic R, Protic, Stretenovic L, and Stoisevic LJ. 1998. The biodegradation of Wheat straw by *Pleurotus ostreatus* mushrooms and its use in cattle feeding. J Anim Feed Sci and Technol 71: 357-362.

Anggraeny YN, and Umiyasih U. 2004. Strategi pemberian pakan berbahan biomass lokal pada peternak sapi potong komersial; studi perbaikan pakan pada usaha penggemukan. Prosiding Seminar Nasional Teknologi Peternakan dan Veteriner. Bogor, 4-5 Agustus 2004. hlm 72-77.

Beever DE, and Mould FL. 2000. Forage Evaluation for Efficient Ruminant Livestock Production. *In*: Given DI, Owen I, Axford RFE, Omed HM, editors. Forage Evaluation in Ruminant Nutrition. Wallingford: CABI Publishing.

Broudiscou, Dobnani LPA, Papon Y, Cornu A, and Grenet E. 2003. Rice straw degradation and biomass synthesis by rumen micro-organisms in continuous culture in response to ammonia treatment and legume extract supplementation. Anim. Feed Sci. Technol.105:95-108

Deborah KH, Mariana N, Jacob N, and Katipana GF. 2005. Pengaruh probiotik terhadap kemampuan cerna mikroba rumen sapi Bali. Prosiding Seminar Nasional Teknologi Peternakan dan Veteriner. Bogor, 12-13 September 2005. hlm 171-180.

[DITJENAK] Direktorat Jenderal Peternakan. 2008. Jakarta: Statistik Peternakan Departemen Pertanian RI.

Eun JS, Beauchemin KA, Hong SH, and Bauer MW. 2006. Exogenous enzymes added to untreated or ammoniated rice straw effect on *in vitro* fermentation characteristics and degradability. J. Anim Feed Sci and Technol 131: 86-101.

Kardaya D, Deden S dan Dede Dj. 2006. Model kerja amoniasi dalam meningkatkan kandungan nitrogen dan kecernaan bahan organik hijauan pakan [laporan penelitian]. Kegiatan program penelitian dasar perguruan tinggi tahun anggaran 2006. Universitas Djuanda.

Leng RA. 1991. Application of Biotechnology to Nutrition of Animal in Developing Countries. FAO Animal Production and Health Paper. Rome: FAO of the United Nations.

Li, X., Pang Y, Zhang R. 2001. Compositional changes of cottonseed hull substrate during *Pleurotus ostreatus* growth and the effect on feeding value of the spent substrate. J. Bioresourse Technol 80: 157-161.

Mathius IW, Sinurat AP, Manurung BP, Sitompul DM, Azmi. 2005. Pemanfaatan produk fermentasi lumpur bungkil sebagai bahan pakan sapi potong. Prosiding Seminar Nasional Teknologi Peternakan dan Veteriner. Bogor, 12-13 September 2005. hlm 153-160.

Maynard LA, Loosh JK, Hintz HF, Warner RG. 1980. Animal Nutrition. 7th Ed. New York: Mc Graw-Hill Book Company.

Nagaraja TG, Newbold CJ, Van Nevel CJ, Demeyer DI. 1997. Manipulation of Ruminal Fermentation. *In*: Hobson PN, Stewart CS, editors. The Rumen Microbial Ecosystem. 2nd Ed. London: Blackie Academic Professional.

Okano K, Kitagawa M, Sasaki Y, Watanabe T. 2005. Conversion of Japanese red cedar (*Cryptomeria japonica*) into a feed for ruminants by white-rot basidiomycetes. J. Anim Feed Sci and Technol 120: 235-243.

Parakkasi A. 1995. Ilmu Nutrisi dan Makanan Ternak Ruminan. Jakarta: Penerbit Universitas Indonesia (UI-PRESS).

Prasetiyono BWHE, Suryahadi, Toharmat T, Syarief R. 2007. Strategi Suplementasi Protein Ransum Sapi Potong Berbasis Jerami dan Dedak Padi. J Media Peternakan 30 (3): 207- 217.

Preston TR, Leng RA. 1987. Matching Ruminant Production System with Available Resources in the Tropics. Armidale: Penambul Books.

Rai RD, Saxena S. 1990. Extracelluler enzymes and non-structural component during growth of *Pleurotus Sajor- caju* on rice straw. Mush J for the Trop 10: 69-73.

Steel RGD, Torrie JH. 1991. Prinsip dan Prosedur Statistika suatu pendekatan Biometrik. Jakarta: Penerbit P.T. Gramedia.

Suryahadi, Amarullah IK. 1984. Pembuatan "ogrea" sebagai pakan dari hasil ikutan tanaman dan pengolahan ubi kayu yang difermentasi dengan *Aspergillus niger* [laporan penelitian]. DP4M IPB Bogor.

Toharmat, T. 2002. Ruminal degradation characteristic of highly digestible fibrous feed. Jurnal Pengembangan Peternakan Tropis.27:53-60.

Weiss B, Underwood J. 2002. Improving Lower Quality Dry Forages By Ammoniation. Ohio University. Columbus, Ohio: Extension Department of Horticulture and Crop Science.

Winarno, F. G. 1992. Pengantar Teknologi Pakan. Jakarta: Gramedia.