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Research Article
Quality of Palm Fronds and Rice Straw Fermented with Probiotics as Ruminant Feed

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Abstract

Background and Objective: Palm fronds and rice straw are agricultural wastes that have the potential to be utilized as feed for ruminants but have low quality. The high fraction of crude fibre of palm fronds and rice straw, namely, cellulose, hemicellulose and lignin, causes their use as feed to be limited. Therefore, it is necessary to improve the quality through fermentation that involves such microorganisms as the bacteria found in probiotics. Probiotics containing cellulolytic, mannanolytic and lactic acid bacteria represent a notable opportunity to improve the quality of feed ingredients. This study aimed to determine the nutritional contents of palm fronds and rice straw fermented with probiotics containing cellulolytic, mannanolytic and lactic acid bacteria. **Materials and Methods:** This study employed a completely randomized design with a 3×3 factorial pattern and with 4 replicates. Factor A is the percentage of probiotics, namely, A1 = 0%, A2 = 2% and A3 = 4% and factor B is the waste used, namely, B1 = palm frond B2 = rice straw and B3 = 50% palm frond + 50% rice straw. **Results:** The results showed that there was an interaction between the provision of probiotics and agricultural waste (palm fronds and rice straw). The interaction between the provision of 4% probiotics with the combination of palm fronds and rice straw (A3B3) showed that the contents of crude protein, crude fat, phosphorus and NDF were better than for the other combinations. As much as 4% of probiotics in rice straw showed the best contents of calcium, crude fibre, ADF and cellulose. The interaction between 2% probiotics and rice straw (A2B2) exhibited the best lignin content. The fermentation treatment using probiotics produced a positive response in reducing the fibre fraction. **Conclusion:** The provision of 4% probiotics in the combination of palm fronds and rice straw demonstrated an increase in quality values.

Key words: Palm fronds, rice straw, fermentation, probiotics, agricultural waste

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Ruminants are meat-producing livestock and are classified as livestock that are able to consume high-fibre feed. The main obstacle in raising ruminants is the availability of feed, which is getting increasingly difficult as a result of land use change. Therefore, we need alternative feed derived from agricultural waste as a substitute for grass.

Agricultural wastes, such as rice straw and palm fronds, can be used as sources of feed but these two types of waste have constraints as feed ingredients, namely, low quality and a high fibre content[1,2]. The crude fibre content of palm fronds reaches 70%, with the lignin content reaching 20% of the dry biomass[3], while rice straw contains 37.71% cellulose, 21.99% hemicellulose; and 16.62% lignin. The high crude fibre fraction consisting of cellulose, hemicellulose and lignin causes its utilization to be limited[4,5]. Therefore, it is necessary to improve the quality through fermentation. The fermentation process involves microorganisms (probiotics) that degrade feed. One of the probiotics that involves cellulolytic, mannanolytic and lactic acid bacteria has the opportunity to improve the quality of feed from agricultural waste.

Fermentation technology is a strategic step in improving feed quality by involving several microorganisms such as moulds and bacteria[3,6]. The involvement of microorganisms in fermentation can degrade crude fibre as well as reduce the levels of lignin and anti-nutritional compounds so that the digestibility value of feed can be increased[7,8]. The fermentation of palm fronds using Effective Microorganism-4 as an inoculant can improve the quality of feed for ruminants. Mardalena *et al.*[9] stated that the fermentation of palm fronds using probiotics containing lactic acid bacteria can increase digestibility and the volatile fatty acid (VFA) concentration in the rumen of dairy cows. One source of microorganisms for feed fermentation is probiotics, which contain a consortium of cellulolytic, mannanolytic and lactic acid bacteria.

To increase the availability of nutrients and to break down lignocellulosic bonds, several physical and chemical delignification methods have been used in agricultural by-products such as wheat straw and rice straw[10,11]. The use of probiotics helps the process of breaking down lignin, cellulose and hemicellulose into simpler compounds, such as glucose[12]. This study was conducted to determine the quality of palm fronds and rice straw fermented with probiotics as feed for ruminants.

MATERIALS AND METHODS

This study used freshly harvested palm fronds, rice straw and probiotics, which contain a consortium of cellulolytic, mannanolytic and lactic acid bacteria. Palm fronds and rice straw were mashed using a chopper to a size of 1-3 cm.

This study used a completely randomized design (CRD) with a 3×3 factorial pattern and 4 replications, where factor A was the provision of probiotics, namely, A1 = 0%, A2 = 2% and A3 = 4% and factor B was agro-industrial waste, namely, B1 = palm fronds, B2 = rice straw and B3 = 50% palm fronds +50% rice straw.

Fermentation was carried out by mixing the feed ingredients of palm fronds and rice straw with different probiotic percentages (0, 2 and 4%) based on dry agricultural waste and then putting them into tightly closed plastic jars. After 21 days, the quality of the fermented feed was measured. The dry matter (DM), ash content (AC), crude protein (CP), crude fat (CFat), crude fibre (CF), phosphorus, calcium and energy (GE) were determined using the methods of the AOAC[13]. The ADF (acid detergent fibre), NDF (neutral detergent fibre), lignin, cellulose and hemicellulose were determined using a previously described method[14].

Statistical analysis: All data were analysed using 2-way analysis of variance (ANOVA) based on a 3×3 factorial pattern. If the main effect was found significant ($p<0.05$), then any differences were assessed using Duncan's multiple range test (DMRT)[15].

RESULTS AND DISCUSSION

The nutritional contents of fermented agricultural waste (palm fronds and rice straw) using probiotics containing a consortium of cellulolytic, mannanolytic and lactic acid bacteria are presented in Table 1.

The interaction between the provision of probiotics and the type of agricultural waste had no significant effect ($p>0.05$) on the dry matter of the fermented feed. Probiotics had no significant effect ($P> 0.05$) on the dry matter content but the type of agricultural waste had a significant effect ($p<0.05$) on the dry matter content of fermented feed.

The dry matter content of rice straw (B2) was higher than that of palm fronds (B1) as well as the combination of rice straw and palm fronds (B3). The high dry matter content of rice straw is thought to be due to the physical texture of rice straw, which is coarser so less water absorption takes place during the fermentation process and thus, the dry matter content is higher. During the fermentation process, there is a decrease in dry matter and an increase in the water content caused by the first fermentation stage, namely, respiration, which is still ongoing, in which glucose is converted into CO_2, H_2O and heat[16]. Another factor that causes this difference is that the high dry matter content of a material will affect the

Table 1: Nutritional contents of palm fronds and rice straw fermented with probiotics

Treatments	Dry matter (%)	Ash content (%)	Crude protein (%)	Crude fat (%)	Phosphorus (%)	Calcium (%)	Energy (kcal)
Probiotic							
A1	72.40	1.45	4.69^{a}	1.91^{a}	0.25^{a}	0.76^{a}	3610.00^{a}
A2	71.97	1.59	5.21^{b}	2.50^{b}	0.27^{b}	1.00^{b}	3652.67^{a}
A3	71.03	1.64	5.67^{c}	2.99^{c}	0.35^{c}	1.13^{c}	3743.67^{b}
Agricultural waste							
B1	68.38^{a}	1.67	4.69^{a}	2.34^{a}	0.12^{a}	0.91^{a}	3159.33^{a}
B2	76.13^{b}	1.48	4.57^{a}	2.56^{b}	0.21^{b}	1.46^{b}	4170.33^{b}
B3	70.88^{c}	1.52	6.31^{b}	2.50^{ab}	0.56^{a}	0.52^{c}	3676.67^{c}
Interaction							
A1B1	69.23	1.60	3.96^{h}	2.00^{g}	0.10^{h}	0.55^{g}	4102.00^{bc}
A1B2	77.22	1.37	4.40^{h}	2.00^{g}	0.16^{ef}	1.26^{c}	3149.00^{g}
A1B3	70.74	1.39	5.71^{c}	1.00^{g}	0.50^{c}	0.48^{i}	3594.00^{ef}
A2B1	68.29	1.69	4.55^{f}	2.50^{cd}	0.12^{g}	1.07^{e}	4169.00^{ab}
A2B2	76.10	1.50	4.49^{fg}	2.50^{cde}	0.17^{e}	1.42^{b}	3149.00^{g}
A2B3	71.51	1.57	6.59^{ab}	2.50^{cdef}	0.53^{b}	0.49^{h}	3640.00^{e}
A3B1	67.64	1.72	5.57^{cd}	3.00^{b}	0.14^{fg}	1.09^{d}	4240.00^{a}
A3B2	75.05	1.59	4.84^{e}	2.50^{c}	0.29^{d}	1.70^{a}	3195.00^{g}
A3B3	70.40	1.61	6.62^{a}	2.90^{a}	0.65^{a}	0.60^{f}	3796.00^{d}

Means in a column followed by different subscripts differ significantly (p<0.05).

dry matter content produced. The dry matter content of palm fronds is 48.78%[17], while that of rice straw is 76.93%[18]. This result is consistent with the statement of Hamid *et al.*[19] that the decrease in the dry matter content in the fermentation process is due to the catabolism of complex compounds into simple compounds by freeing water molecules.

There was no significant interaction between the provision of probiotics and the type of agricultural waste on the ash content of fermented feed (p>0.05). This result agrees with a previous study conducted by Kusumaningrum *et al.*[20], who stated that various *Asperglus niger* treatments and curing times did not show any interaction with the ash content. According to Zakaria *et al.*[21], the ash content aims to determine the amount of mineral content contained in feed ingredients. The determination of the ash content is closely related to mineral content as well as colour and texture of feed ingredients. The ash content determines the level of organic matter from a feed and ash is an inorganic material in feed ingredients.

There was a significant interaction (p<0.05) between the provision of probiotics and agricultural waste on the fermented feed crude protein content. The highest feed protein content was found in the A2B3 and A3B1 interactions. The high crude protein content is thought to be because these samples contain better digestible carbohydrates and the bacteria contained in probiotics are able to work well in utilizing carbohydrates in the combination of fronds and straw. The carbohydrate content contained in the substrate is optimally utilized by lactic acid bacteria as nutrients for growth so that in fermentation, lactic acid bacteria develop more[22]. Similar results were reported by Chanjula *et al.*[8], who stated that the nutrient digestion coefficient (DM, OM, CP, NDF and ADF) significantly increased in palm fronds treated with white rot fungi.

There was a significant interaction (p<0.05) between the provision of probiotics and agricultural waste on the crude fat content of fermented feed. Likewise, probiotic treatment alone and agricultural waste alone had a significant effect (p<0.05) on the crude fermented feed fat. The combination of palm fronds and rice straw with 4% probiotics gave the highest feed fat content (2.90%). Fat is an important source of energy for cell mass development and is used as a source of energy for body metabolism[12].

There was an interaction (p<0.05) between the provision of probiotics and agricultural waste on the phosphorus and calcium contents of fermented feed. The highest phosphorus content is found in the A3B3 interaction. The high phosphorus content is thought to be due to the provision of probiotics in the combination of midrib and straw increasing the phosphorus content. This is in accordance with the opinion of Hidayati, *et al.*[23], who stated that the phosphorus content is influenced by the nitrogen of the material and the higher the nitrogen content is, the higher the multiplication of microorganisms that break down phosphorus, thus causing the phosphorus content to also increase.

The results showed that the best calcium content (17%) was found in the A3B2 interaction. This high calcium content is thought to be higher than the calcium content in palm fronds. However, from the results of the study, the Ca content is lower than that found in the research of Shen *et al.*[24], indicating that the straw has a mineral content that depends on the harvest season, namely, at the beginning of the harvest season, the content is as much as 2.21%.

Table 2: Fibre contents of palm fronds, rice straw and the combination of frond-straw

Treatment	Crude fibre (%)	ADF (%)	NDF (%)	Cellulose (%)	Hemicellulose (%)	Lignin (%)
Probiotic						
A1	32.92[a]	57.83[a]	75.00[c]	18.58[a]	17.51	10.07[a]
A2	31.00[b]	55.96[b]	72.57[b]	18.17[a]	16.20	9.65[b]
A3	30.00[c]	50.25[c]	66.32[a]	20.08[b]	16.15	9.09[b]
Agricultural waste						
B1	36.67[a]	53.36[a]	69.06[a]	16.83[a]	15.70	12.15[a]
B2	26.33[b]	56.25[b]	71.08[b]	25.58[c]	17.58	6.07[b]
B3	30.92[c]	54.42[ab]	73.75[c]	14.42[c]	16.58	10.60[c]
Interaction						
A1B1	38.50[a]	60.50[a]	69.72[ef]	24.54[de]	17.00[ab]	12.77[a]
A1B2	28.50[g]	54.12[ef]	77.50[a]	15.25[abc]	19.25[ab]	6.58[g]
A1B3	31.75[d]	55.75[cd]	76.00[ab]	27.00[de]	16.00[ab]	10.87[d]
A2B1	36.50[b]	58.25[ab]	68.50[fg]	16.00[de]	16.78[ab]	12.15[b]
A2B2	25.50[h]	51.25[ef]	75.25[abcd]	14.00[ab]	18.25[ab]	6.22[gh]
A2B3	31.00[de]	54.73[bcd]	71.50[de]	25.25[e]	15.61[ab]	10.59[de]
A3B1	35.00[c]	58.00[c]	65.96[g]	16.00[d]	14.71[ab]	11.53[c]
A3B2	25.00[h]	49.25[f]	72.75[d]	13.25[a]	17.50[ab]	5.40[i]
A3B3	30.00[ef]	50.25[ef]	64.50[h]	19.25[e]	14.50[ab]	10.33[ef]

Means in a column followed by different subscripts differ significantly ($p<0.05$).

There was no significant interaction ($p>0.05$) between the provision of probiotics and the type of agricultural waste on the energy content of the fermented feed produced. The highest energy was found in the interaction of 4% probiotics with palm fronds (A3B1).

The contents of fibre, ADF, NDF, cellulose, hemicellulose and lignin of palm fronds, rice straw and a combination of frond-straw treated with probiotics can be seen in Table 2.

There is an interaction ($p<0.05$) between the provision of probiotics and agricultural waste on the crude fibre in the fermented feed. The best interaction is found in A2B2 treatment. The low content of crude fibre in fermented feed is thought to be because the cellulolytic and mannanolytic microbes contained in the probiotics are able to synergistically change complex compounds into simpler compounds. Cellulolytic bacteria are bacteria that can hydrolyse cellulose complexes into smaller oligosaccharides and eventually become glucose[25,26]. Meanwhile, microorganisms that produce the enzyme mannanase can hydrolyse hemicellulose into the form of manooligosaccharides[14,27]. Mannanase is an enzyme that breaks down mannose and galactomannan into mannose and galactose. This enzyme randomly cuts the main chains of mannan and hetero β-D-mannan into dissolved sugars, namely, mannodextrins and mannose[28].

According to Wina[29], the fermentation process can improve the quality of waste feed due to the presence of microorganisms that can degrade crude fibre and reduce lignin and anti-nutritional compounds so that the feed digestibility increases. This is in accordance with the research of Astuti and Yelni[26], who found that fermentation using MOL (local microorganism) starter produces a dry matter digestibility 32.20% higher than the control.

There was a significant interaction between the provision of probiotics and agricultural waste on the fermented feed ADF and NDF ($p<0.05$). Probiotics at the 4% level in rice straw (A3B2) showed the lowest ADF content. The best NDF interaction was found in the provision of 4% probiotics in mixed agricultural waste (palm fronds and rice straw) (A3B3). The high NDF content of rice straw (B2) compared to palm fronds (B1) is suspected because rice straw has a higher NDF content than palm fronds. This is in accordance with the results of research by Syamsu *et al.*[30], who stated that the NDF content in straw was 72.52%, while the NDF content in palm fronds was 65.59%[16]. According to Rahman *et al.*[3], the lower contents of ADF and NDF in palm fronds after being given the fungus is an indication of cell wall damage due to the presence of fungi.

These results indicate that the fermentation process using probiotics can increase the nutritional value of palm fronds and rice straw, which can reduce the content of cell walls. Sarnklong *et al.*[4] stated that high ADF and lignin contents in the ration could result in a lower digestibility of the ration. Structural changes in cell wall components due to the provision of probiotics can facilitate microbes in the rumen to degrade high-fibre rations and thus, they can increase feed digestibility[31].

There was an interaction between the provision of probiotics and agricultural waste in the cellulose and hemicellulose in the fermented feed ($p<0.05$). The lowest cellulose content was found in the provision of 4% probiotic and rice straw (A3B2). The low content of crude fibre is suspected to result from that cellulolytic microbes contained in probiotics are able to break down complex compounds into simpler compounds. The presence of probiotics that involve cellulolytic, mannanolytic and lactic acid bacteria can certainly help the process of breaking down the feed fibre. Cellulase enzymes are able to degrade cellulose into cellobiose or glucose. The degradation of cellulose requires three enzymes, namely, endoglucanases, cellobiohydrolases and glucosidases[32]. Endoglycanase enzymes can break down cellulose into shorter oligosaccharides and then, the cellobiohydrolase enzyme can continue the degradation of shorter oligosaccharides to cellobiose, which is broken down by glucosidases converting cellulose to D-glucose.

Some microorganisms produce enzymes for cellulose decomposition, such as cellodextrinase, which can remove disaccharides from cello-oligosaccharides. Enzymes that can also degrade cellulose are cellodextrin phosphorylase, cellobiose phosphorylase and cellobiose epimerase[33].

The results of this study indicated that there was an interaction ($p<0.05$) between the provision of probiotics and agricultural waste on the fermented feed lignin. The low lignin content in the A3B2 interaction is thought to be because probiotics are able to remodel complex compounds into simpler compounds. The use of probiotics in the fermentation of agricultural waste shows a decrease in the crude fibre content. Increasing the level of probiotics is directly proportional to a decrease in the lignin content. This is in accordance with the opinion of Ratnakomala *et al.*[34] stating that the addition of inoculum will accelerate the fermentation process and more substrate is degraded so that it can reduce the content of feed fibre. Microorganisms have the ability to degrade lignin in feed ingredients and thus, they can increase digestibility in the rumen. Microorganisms that are good for lignocellulose bioconversion are those that have the ability to decompose lignin but have low degradations of cellulose and hemicellulose[6,35].

CONCLUSION

The quality of the fermentation was good at the interaction of 4% probiotics on rice straw waste, resulting in the highest protein content and the lowest crude fibre content.

REFERENCES

1. Kawamoto, H., W.Z. Mohamed, N.I.M. Shukur, M.S.M. Ali, Y. Ismail and S. Oshio, 2001. Palatability, digestibility and voluntary intake of processed oil Palm fronds in cattle. Jap. Agric. Res. Quart., 35: 195-200.
2. Herlinae, Yemima and Rumiasih, 2015. Pengaruh aditif EM4 dan gula merah terhadap karakteristik silase rumput gajah (*Pennisetum purpureum*) [Effect of additives EM4 and palm sugar on the characteristics of elephant grass (*Pennisetum purpureum*) silage]. J. Ilmu Hewani Tropika, 4: 27-30. (In Indonesian)..
3. Rahman, M.M., M. Lourenco, H.A. Hassim, J.J.P. Baars and A.S.M. Sonnenberg *et al.*, 2011. Improving ruminal degradability of oil palm fronds using white rot fungi. Anim. Feed Sci. Technol., 169: 157-166.
4. Sarnklong, C., J.W. Cone, W.F. Pellikaan and W.H. Hendriks, 2010. Utilization of rice straw and different treatments to improve its feed value for ruminants: A review. Asian-Aust. J. Anim. Sci., 23: 680-692.
5. Yanuartono, H. Purnamaningsih, S. Indarjulianto and Alfarisa Nururrozi, 2017. Potensi jerami sebagai pakan ternak ruminansia. Ind. J. Anim. Sci., 27: 40-62.
6. Nguyen, D.V., C.C. Vu and T.V. Nguyen, 2020. The current utilisation and possible treatments of rice straw as ruminant feed in Vietnam: A review. Pak. J. Nutr., 19: 91-104.
7. Sandi, S., E.B. Laconi, A. Sudarman, K.G. Wiryawan and D. Mangundjaja, 2010. Kualitas nutrisi silase berbahan baku singkong yang diberi enzim cairan rumen sapi dan leuconostoc mesenteroides [Nutritive quality of cassava-based silage added caĴle rumen liquor enzyme and *Leuconostoc mesenteroides*]. Media Peternakan, 33: 25-30 (In Indonesian).
8. Chanjula, P., V. Petcharat and A. Cherdthong, 2018. Rumen characteristics and feed utilization in goats fed with biologically treated oil palm fronds as roughage in a total mixed ration. South Afr. J. Anim. Sci., 48: 1049-1056.
9. Mardalena, S. Syarif, S. Erina 2016. Molecular Characteristics and Identification of Lactic Acid Bacteria of Pineapple Waste as Probiotics Candidates for Ruminants Pak. J. Nutr., 15: 519-523.
10. Hamed, A.H.M. and M.E. Elimam, 2010. Performance and digestibility in Nubian goats fed steam treated sorghum stover. Pak. J. Nutr., 9: 298-301.
11. Shah, A.A., Y. Xianjun, D. Zhihao, L. Junfeng and T. Sao, 2018. Microbiological and chemical profiles of elephant grass inoculated with and without Lactobacillus plantarum and *Pediococcus acidilactici*. Arch. Microbiol., 200: 311-328.
12. Shah, A.A., Y. Xianjun, D. Zhihao, W. Siran and S. Tao, 2017. Effects of lactic acid bacteria on ensiling characteristics, chemical composition and aerobic stability of king grass. J. Anim. Plant Sci., 27: 747-755.
13. Al-Mentafji, H.N., 1990. Association of Official Analytical Chemists. 15th Edn., Washington, D.C.
14. Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 3583-3597.

15. Steel,, R.G.D., J.H. Torrie and D.A. Dickey, 1996. Principles and Procedures of Statistics: A Biometrical Approach. Subsequent Edn., McGraw-Hill College Washington, D.C., Pages: 672.
16. Nguyen, D.V. and L.H. Dang, 2020. Fresh rice straw silage affected by ensiling additives and durations and its utilisation in beef cattle diets. Asian J. Anim. Sci., 14: 16-24.
17. Imsya, A. and R. Palupi, 2009. Perubahan kandungan lignin, neutral detergent fiber (NDF) dan acid detergent fiber (ADF) pelepah sawit me lalui proses biodegumming sebagai sumber bahan pakan serat ternak ruminansia [Changes in the content of lignin, neutral detergent fiber (NDF) and acid detergent fiber (ADF) of palm fronds through the biodegumming process as a feed source of ruminant animal fiber]. Jurnal Ilmu Ternak Veteriner, 14: 284-288 (In Indonesian).
18. Prasetiyono, B.W.H.E., Suryahadi, T. Toharmat and R. Syarief, 2017. Strategi suplementasi protein ransum sapi potong berbasis jerami dan dedak padi. Media Peternakan, 30: 207-217.
19. Hamid, H., T. Purwadaria, T. Haryati and A.P. Sinurat, 1999. The changes of peroxide number of coconut meal during storage and fermentation processed with *Aspergillus niger*. J. Ilmu Ternak Veteriner, 4: 101-106.
20. Kusumaningrum, M., C.I. Sutrisno and B.W.H.E. Prasetyono, 2012. Kualitas kimia ransum sapi potong berbasis limbah pertanian dan hasil samping pertanian yang difermentasi dengan *Aspergillus niger* [Chemical quality of cattle feed and agricultural waste based agricultural by-product fermented with *Aspergillus niger*]. Anim. Agric. J., 1: 109-119 (In Indonesian).
21. Zakaria, Y., C.I. Novita and S. Samadi, 2013. Efektivitas fermentasi dengan sumber substrat yang berbeda terhadap kualitas jerami padi. J. Agripet, 13: 22-25.
22. Fritsch, C., R.F. Vogel and S. Toelstede, 2015. Fermentation performance of lactic acid bacteria in different lupin substrates—influence and degradation ability of antinutritives and secondary plant metabolites. J. Applied Microbiol., 119: 1075-1088.
23. Hidayati, Y.A., T.B.A. Kurnani, E.T. Marlina and E. Harlia, 2011. Kualitas pupuk cair hasil pengolahan feses sapi potong menggunakan saccharomyces cereviceae (Liquid fertilizer quality produced by beef cattle feces fermentation using saccharomyces cereviceae). J. Anim. Sci., 11: 104-107 (In Indonesian).
24. Shen, H.S., F. Sundstol, E.R. Eng and L.O. Eik, 1999. Studies on untreated and urea-treated rice straw from three cultivation seasons. 3: Histological investigations by light and scanning electron microscopy. Anim. Feed Sci. Technol., 80: 151-159.
25. Ibrahim, A.S.S. and A.I. El-diwany, 2007. Isolation and identification of new cellulases producing thermophilic bacteria from an Egyptian hot spring and some properties of the crude enzyme. Aust. J. Basic Applied Sci., 1: 473-478.
26. Astuti, T. and G. Yelni, 2015. Evaluation of nutrient digestibility on palm oil frond fermented with some microorganism as ruminant feed. J. Sain Peternakan Indonesia, 10: 101-106.
27. Meryandini, A., R. Anggreandari and N. Rachmania, 2008. Isolasi bakteri mananolitik dan karakterisasi mananasenya. Biota, 13: 82-88.
28. Johnson, K.G., 1990. Exocellular β-mannanases from hemicellulolytic fungi. World J. Microbiol. Biotechnol., 6: 209-217.
29. Wina, E., 2005. [The technology of utilizing microorganism in feed to improve ruminant productivity in Indonesia: A review]. Wartazoa, 15: 173-186.
30. Syamsu, J.A., 2006. Kajian Penggunaan Starter Mikroba dalam Fermentasi Jerami Padi pada peternakan Rakyat di Sulawesi Tenggara. Proceeding of Nasional Bioteknologi 2006, November 15-16, 2006 Pusat Penelitian Bioteknologi Lembaga Ilmu Pengetahuan Indonesia 298-300.
31. Wanapat, M., 2000. Rumen manipulation to increase the efficient use of local feed resources and productivity of ruminants in the tropics. Asian-Aust. J. Anim. Sci., 13: 59-67.
32. Brink, J.v.d. and R.P.d. Vries, 2011. Fungal enzyme sets for plant polysaccharide degradation. Applied Microbiol. Biotechnol., 91: 1477-1492.
33. Sharma, A., R. Tewari, S.S. Rana, R. Soni and S.K. Soni, 2016. Cellulases: classification, methods of determination and industrial applications. Applied Biochem. Biotechnol., 179: 1346-1380.
34. Ratnakomala, S., R. Ridwan, G. Kartina and Y. Widyastuti, 2006. Pengaruh Inokulum *Lactobacillus plantarum* 1A-2 dan 1BL-2 terhadap Kualitas Silase Rumput Gajah (*Pennisetum purpureum*) [The effect of *Lactobacillus plantarum* 1A-2 and 1BL-2 inoculant on the quality of napier grass silage]. Biodiversitas, 7: 131-134 (In Indonesian).
35. Mugiawati R.E., Suwarno and N. Hidayat, 2013. Kadar air dan ph silase rumput gajah pada hari ke -21 dengan penambahan jenis additive dan bakteri asam laktat [Moisture and pH of elephant grass silage on 21st day with the types of additive and addition of lactic acid bacteria]. Anim. Sci. J., 1: 201-207.