PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 14 (12): 988-993, 2015
ISSN 1680-5194

Evaluation of Yeast Supplementation with Urea-Molasses in Rice Straw-Based Diets on *in vitro* Ruminal Fermentation

A.I.M. Ali[1], S. Sandi[1], Riswandi[1], A. Imsya[1], A. Prabowo[2] and N. Rofiq[3]
[1]Department of Animal Science, Faculty of Agriculture, University of Sriwijaya,
Jl. Palembang-Prabumulih km 32, Indralaya, Ogan Ilir, Sumatera Selatan, 30662, Indonesia
[2]South Sumatra Agricultural Institute for Assessment Technology,
Balai Pengkajian Teknologi Pertanian (BPTP), Sumatera Selatan, Indonesia
[3]Agency for The Assessment and Application of Technology,
Badan Pengkajian dan Penerapan Teknologi, (BPPT), Indonesia

Abstract: The effects of yeast supplementation on *in vitro* fermentation characteristics of rice straw and urea-molasses diets in Indonesian swamp buffalo were examined; five doses of yeast (0, 2.5, 5.0, 7.5 and 10 g/head/d) were tested. The results indicated that yeast supplementation increased dry and organic matter, neutral detergent fiber (NDF), cellulose and hemicellulose degradability, ammonia-nitrogen and total volatile fatty acid concentration and decreased the ruminal pH but had no effect on acid detergent fiber (ADF) degradability or cellulolytic bacterial or protozoan populations. Supplementation with yeast supported ruminal fermentation of urea-molasses and rice straw-based diets, with 5.0 g yeast/head/d showing the greatest response for most variables tested.

Key words: Yeast, degradability, cellulolytic bacterial and protozoan populations

INTRODUCTION

The grazing of buffalo in nontidal swamps in Lebak, South Sumatra (Indonesia) has long since been an effort to utilize deep swamps for meat and milk production. However, the population of swamp buffalo in some subdistricts of South Sumatra have declined due to poor management and especially insufficient feed supplies during the dry season (Ali *et al*., 2013a). Like other ruminants in developing countries, swamp buffalo in these sub districts are predominantly maintained on low-grade roughage, resulting in poor nutrient utilization and productivity. Therefore, forages must be enhanced in accordance with the swamp agroecosystem. One way to do so is through utilization of Lebak swamp rice straw to enhance forage supplies in the dry season.

Rice straw production each year is plentiful in South Sumatra and can potentially overcome the shortage of ruminant feed. The South Sumatra Central Bureau of Statistics recorded swamp paddy production of dry unhulled rice to be around 1.65 million tons in 2011 (Biro Pusat Statistik, 2012). On average, 0.83 kg of straw is produced with each kilogram of paddy grain (Trach, 1998), resulting in 1.37 million tons of rice straw produced in swamp areas. However, there are some limitations to utilizing rice straw as ruminant feed. Rice straw consists predominantly of cellulose, hemicellulose and lignin and ruminant organisms need other nutrients for growth and metabolism (Hoover, 1986). Since rice straw does not contain enough sugars, amino acids and minerals for efficient microbial growth, feeding ruminants only rice straw without further supplementation results in poor performance (Doyle *et al*., 1986). Supplementation of rice straw rations with protein, energy and/or minerals, such as molasses, multi nutrient blocks, green leaves, crop residues and locally available agro-industrial by products may optimize rumen function, while maximizing utilization of rice straw.

Urea-molasses is widely used for supplementation of swamp buffalo (Ali *et al*., 2013b; Tanwar *et al*., 2013; Thu and Uden, 2000, 2001; Tiwari *et al*., 1990) and other ruminants (Vu *et al*., 1999; Wanapat *et al*., 1999; Akter *et al*., 2004) with straw-based diets. Moreover, yeast (*Saccharomyces cereviseae*) supplementation can beneficially modify microbial activity, fermentation and digestive functions in the rumen. Most investigators agree that yeast can have measurable effects on ruminal fermentation and results in beneficial changes in digestion. However, there are limited reports regarding yeast supplementation of high roughage rations with urea-molasses and rice straw-based diets. The main objectives of the current study were to investigate the effect yeast supplementation on *in vitro* ruminal fermentation of urea-molasses with rice straw-based diets.

Corresponding Author: A.I.M. Ali, Department of Animal Science, Faculty of Agriculture, University of Sriwijaya, Jl. Palembang-Prabumulih km 32, Indralaya, Ogan Ilir, Sumatera Selatan, 30662, Indonesia

MATERIALS AND METHODS

Substrate and rumen liquor preparation: The substrate for *in vitro* ruminal fermentation was a dry matter-based mixed rations of rice straw 80 and 20% urea-molasses supplementation (1.85% urea, 5.94% molasses, 4.83% rice bran, 3.50% tofu-waste, 2.05% cassava meal, 0.92% NaCl, 0.49% limestone flour, 0.36% trisodium phosphate and 0.05% mineral and vitamin premix). Diets were estimated according to the requirements of a 200-kg swamp buffalo with a 5.22-kg dry matter intake and 0.62-kg weight change per day (Thu and Uden, 2001). The chemical composition of diets is reported in Table 1.

Rice straw (*Oryza sativa* var. ciherang) was harvested on August 2014 from the swamp paddy field in the Rambutan subdistrict of Banyuasin district, chopped, dried in an oven (60°C) and ground to 1 mm. Rice bran, limestone flour and trisodium phosphate were obtained from a traditional market in the Ogan Ilir district. Solid tofu waste (local name: "ampas tahu") from the local tofu industry was dried in an oven (60°C) after being milled and extracting the soybeans. Cassava meal was prepared from bitter cassava roots from the traditional market, cut into thin slices and sun-dried. All ingredients were ground and sifted through a 1 mm. The mineral and vitamin premix (Cattle Mix) contained 1 g Mg/kg, 1 g Co/kg, 3.3 g P/kg, 7 g Ca/kg, 6.5 g Na/kg, 1 g S/kg, 50 mg Fe/kg, 40 mg Mn/kg, 30 mg Zn/kg, 8 mg Cu/kg, 500 μg I/kg, 200 μg Se/kg, 30,000 IU vitamin A/kg, 3500 IU vitamin D/kg and 900 IU vitamin E/kg. The yeast used for supplementation was Yea-Sacc^{1026}, a yeast culture with a declared concentration of 10^9 CFU/g, 34.58% crude protein, 7.2% crude fat, 10.44% ADF and 7.42% ash.

The dry matter content was determined by oven-drying at 105°C for 24 h. The organic matter was determined by ashing at 550°C for 4 h. Total nitrogen content was determined according to the Kjeldahl method (AOAC, 1995). The content of NDF, ADF, cellulose and hemicellulose was determined using the method reported by Van Soest *et al*. (1991). Rumen liquor was collected from swamp buffalo rumen at a slaughter house. These buffalo were fed a diet consisting of *Oryza rupifogon*, *Eleocharis dulcis* and *Hymenachne acutigluma* in the Rambutan subdistrict of Banyuasin district, South Sumatra province. Ruminal contents from buffalo were strained through two layers of cheese cloth and kept at 39°C under a CO_2 atmosphere.

***In vitro* fermentation (Tilley and Terry, 1963):** The substrate (1 g) was put into a 100-ml fermentation tube and 40 ml of McDougall buffer and 10 ml of rumen liquor were added. McDougal buffer solution (6 L) contained 58.8 g $NaHCO_3$, 42 g $Na_2HPO_4 \bullet 7H_2O$, 3.42 g KCl, 2.82 g NaCl, 0.72 g $MgSO_4 \bullet 7H_2O$, 0.24 g $CaCl_2$. The mixture was stirred and flushed with O_2-free CO_2 and then the tubes were sealed with a rubber fitted with the gas release valve. All fermentation tubes were incubated in a shaking water bath at 39°C for 48 h.

Estimation of volatile fatty acid (VFA) and ammonia-nitrogen (N-NH_3) concentration and *in vitro* degradability: Measurement of total VFA content was done using a previously reported steam distillation method (General Laboratory Prosedures, 1966) and the N-NH_3 concentration was determined using a previous microdiffusion method (Conway, 1962). The total VFA concentration in ruminal fluid was determined by Markham's distillation. To determine the *in vitro* degradability of dry and organic matter, NDF, ADF, cellulose and hemicellulose (Van Soest *et al*., 1991), the content of the fermentation tube incubated for 48 h was transferred into a new tube and centrifuged at 2500 rpm for 20 min at room temperature. After, the supernatant was discarded and the remaining residue was passed through a filter paper (Whatman No. 41). The residue of each fermentation tube was dried to a constant weight at 105°C for 24 h to determine *in vitro* degradability.

Protozoal and bacterial counts: After a 48-h incubation, a 1 ml aliquot was taken from each fermentation tube for analysis of protozoan and bacterial populations. The contents of the fermentation tube were mixed properly and 1 ml of the sample was mixed with 1 ml methyl green formaldehyde saline solution containing 35% formaldehyde, distilled water, methyl green and NaCl (Ogimoto and Imai, 1981). The stained sample was kept at room temperature and protozoan populations were counted using a counting chamber (0.1 mm) and a microscope (40X objective). Bacterial populations were determined using a roll-tube technique (Hungate, 1969). Statistical Analysis. The completely randomized design of the current study was chosen to evaluate five different doses of yeast (0, 2.5, 5.0, 7.5 and 10 g/head/d) with four replications. Data were analyzed by analysis of variance and mean values were tested for differences using Duncan's New Multi-Range Test.

RESULTS

The chemical composition of the rice straw and urea-molasses, as well as buffalo diet ingredients, are presented in Table 1. pH, VFA and N-NH_3 are important parameters reflecting ruminal environment. Yeast supplementation decreased the ruminal pH by 0.06 units compared to controls (Table 2). The highest pH occurred in samples with 0 g yeast supplementation and the lowest was seen with 7.5 g yeast. Nonetheless, the ruminal pH range in all sample groups was optimal (6.0-6.9). The concentration of N-NH_3 was 7.57, 10.05, 11.07, 9.41 and 10.19 mM with 0, 2.5, 5.0, 7.5 and 10 g yeast, respectively ($p<0.01$; Table 2). VFA concentrations were significantly higher ($p<0.01$) in yeast-supplemented diets (74.63-94.10 mM) compared to the control diet (56.52 mM; Table 2). Results of this trial showed that no significant effects of yeast supplementation on growth of cellulolytic bacterial and protozoan populations.

Table 1: Chemical composition of rice straw and urea-molasses, as well as buffalo diets (% of DM)

Item	DM	OM	CP	NDF	ADF	Lignin	C	HC
Rice straw (80%)+UMS (20%)	86.03	90.07	10.14	63.37	41.15	6.31	29.67	22.22
Rice straw	92.98	83.76	4.83	76.14	47.97	7.07	37.50	28.17
UMS	80.69	66.64	31.41	15.61	11.42	2.78	6.66	4.19
Rice bran	90.67	74.41	6.36	55.79	47.03	11.85	23.95	8.76
Solid Tofu Waste	96.00	93.05	20.29	48.25	23.60	2.64	20.46	24.65
Cassava meal	84.41	83.19	1.85	22.34	5.08	0.82	4.32	17.26

UMS: Urea-molasses supplementation, DM: Dry matter, OM: Organic matter, CP: Crude protein, NDF: Neutral detergent fiber, ADF: Acid detergent fiber, C: Cellulose, HC: Hemicellulose

Table 2: Degradability, rumen pH, N-NH_3, volatile fatty acid (VFA) concentration, bacterial and protozoan populations with yeast supplementation

	Yeast supplementation (g/head/day)						
	0	2.5	5.0	7.5	10	SE	p-value
Degradability							
DM	34.35^{a}	43.22^{b}	48.25^{cd}	46.99^{c}	49.87^{d}	1.32	0.000
OM	33.08^{a}	42.27^{b}	46.86^{c}	46.28^{c}	47.94^{c}	1.31	0.000
NDF	43.29^{a}	44.70^{ab}	45.75^{b}	46.17^{b}	48.61^{c}	0.62	0.010
ADF	48.22	49.52	48.28	49.58	51.04	0.43	0.192
Cellulose	2.99^{a}	6.09^{b}	5.53^{b}	4.51^{ab}	5.47^{b}	0.37	0.028
Hemicellulose	32.65^{a}	40.83^{b}	40.22^{b}	38.41^{ab}	50.28^{c}	1.67	0.001
pH	6.84^{c}	6.82^{bc}	6.83^{c}	6.78^{a}	6.80^{ab}	0.01	0.000
N-NH_3	7.57^{a}	10.05^{b}	11.07^{b}	9.41^{ab}	10.19^{b}	0.37	0.001
Total VFA	56.52^{a}	92.05^{b}	85.88^{b}	74.63^{ab}	94.10^{b}	4.06	0.000
Cellulolytic Bacteria	5.36	5.38	6.09	4.30	5.89	0.29	0.348
Protozoa	4.83	5.10	5.17	4.85	5.05	0.06	0.175

DM: Dry matter; OM: Organic matter, NDF: Neutral detergent fiber, ADF: Aacid detergent fiber

$^{a-d}$Means within a row with different superscripts differ

In vitro degradability of dry and organic matter was increased by supplementation with yeast ($p<0.01$). Dry and organic matter degradability with 5.0 g yeast was similar to that with 7.5 and 10 g yeast but higher than with 0 and 2.5 g ($p<0.01$). Furthermore, yeast supplementation affected NDF degradability but not ADF.

DISCUSSION

The chemical composition of rice straw was similar to results previously reported by Tan *et al*., 1996; Thalib *et al*., 2000 which showed that rice straw had greater NDF, ADF, cellulose and hemicellulose and lower crude protein content compared to the other cereal straw. Moreover, urea-molasses supplementation with locally available products decreased the fiber fraction and increased crude protein content in the diet.

Although there were significant differences on rumen pH among the different yeast treatments in the current study, the differences was small. Ruminal pH affects digestibility of feed stuffs. Fibrolytic bacteria are very sensitive and dependent on pH changes; the digestibility of organic matter, NDF and nitrogen decrease at pH 5.8 and increase at pH 6.2. Production of total VFA content of continuous culture system was shown to be highest between pH 6.2 and 6.6 in high concentrate diets (Shiver *et al*., 1986). Sung *et al*. (2007) reported increases dry matter digestion and VFA production from pH 6.2 to 6.7 after 48 h of *in vitro* rumen fermentation. Dolezal *et al*. (2011) reported that yeast supplementation increased ruminal pH in high concentrate diets, while Mao *et al*. (2013) found that ruminal pH increased in rice straw-but decreased in corn stover-based subtrate diets with yeast supplementation. The current results are consistent with results observed by Lynch and Martin (2002), where live cells of yeast decreased ruminal pH when alfalfa hay was *in vitro*-incubated. These differences in ruminal pH of Lynch and Martin (2002) were likely associated with the lactic acid concentration and differences in substrate degradation with yeast supplementation. Compared with Thu and Uden (2001), the control treatment of the current study had a similar pH but lower concentration of N-NH_3.

Ammonia is the main source of nitrogen for microbial protein synthesis (Bach *et al*., 2005). The present results showed that yeast supplementation increased the N-NH_3 concentration. This is in agreement with Mao *et al*. (2013) who reported a N-NH_3 concentration of 8.0 mg per 100 ml in controls and 8.3-10.5 mg per 100 ml in yeast-supplemented treatments with rice straw based diet. Zain *et al*. (2011) found that yeast supplementation decreased N-NH_3 concentrations in ammoniated rice straw. Opsi *et al*. (2012) reported that yeast supplementation increased N-NH_3 in high forage diets but did not affect in high concentrate diets. It is likely that increases in N-NH_3 output represent microbial degradation of large amounts of yeast cells which have a high protein content.

Supplementation of high-fiber diets with yeast additives affected total VFA production in the current study. This result is consistent with the slight decline in rumen pH discussed above and also agree with the reports of Mao *et al*. (2013), Zain *et al*. (2011) and Opsi *et al*. (2012), among other *in vivo* studies, indicating stimulation of rumen microbial fermentation activity. This alteration in ruminal VFA by yeast supplementation could contribute to improved feed efficiency in swamp buffalo. Wallace and Newbold (1992) suggested that variable responses in VFA production and patterns are a consequence of the effects of yeast on rumen microbial numbers rather than a direct effect on ruminal fermentation.

Data regarding the 48-h degradability of diets in the present study are presented in Table 2; the current results generally agree with previous experiments (Lila *et al*., 2004; Tang *et al*., 2008; Zain *et al*., 2011). Lila *et al*. (2004) reported that *in vitro* dry matter degradability increased with yeast supplementation of sudangrass hay and concentrate mixtures. Zain *et al*. (2011) reported that yeast supplementation increased dry and organic matter, NDF, ADF and cellulose degradability. Herawaty *et al*. (2013) reported that yeast supplementation increased the degradability of organic matter, NDF and ADF more than a diet of rice straw alone.

When yeast was supplemented at 5.0 g/kg, the greatest dry matter degradability occurred for maize stover, maize stover silage and wheat straw but generally decreased with rice straw. On the other hand, yeast supplementation increased organic matter degradability of maize stover, maize stover silage and rice straw (Tang *et al*., 2008). Opsi *et al*. (2012) reported that supplementation of yeast had not effect on dry matter and NDF digestibility in high and low forage ration diets. In the present study, yeast supplementation did not significantly affect bacterial and protozoan numbers in the *in vitro* fermentation test even though they tended to increase. Previous studies have reported that yeast supplementation increased cellulolytic bacteria and protozoa significantly in *in vitro* studies (Mao *et al*., 2013; Newbold *et al*., 1995; Zain *et al*., 2011) and *in vivo* study in buffalo (Kumar *et al*., 2013). However, Hristov *et al*. (2010) and Yoon and Stern (1996) showed that no significant effect of yeast supplementation on protozoan number was observed. Increased dry and organic matter, NDF, cellulose and hemicellulose degradability, as well as VFA production with different yeast supplementation level in the present study could be attributed to an increased fiber-digesting bacterial population.

Conclusions and implications: It is concluded that yeast supplementation of urea-molasses and rice straw diets increases the degradability of dry and organic matter, NDF, cellulose and hemicellulose, the concentration of N-NH_3 and VFA, but decreases the rumen pH. The current results also showed that supplementation with 5.0 g yeast/head/d provides the greatest response for most variables tested. *In vivo* studies of yeast supplementation should be implemented in future to optimize the utilization of dietary nutrients and improve production in buffalo fed low-quality roughage.

ACKNOWLEDGEMENTS

Financial support for this study was provided by a competitive research grant from KKP3N (Kerjasama Kemitraan Penelitian dan Pengembangan Pertanian Nasional) Ministry of Agriculture of Republic Indonesia in 2015. The authors would like to thank the Research Center for Sub-Optimal Lands and Laboratory of Animal Nutrition and Feed Science of Sriwijaya University, as well as the Laboratory of Dairy Science and Technology, Bogor Agricultural University (Bogor, Indonesia) for use of their facilities.

REFERENCES

Akter, Y., M.A. Akbar, M. Shahjalal and T.U. Ahmed, 2004. Effect of urea molasses multi-nutrient blocks supplementation of dairy cows fed rice straw and green grasses on milk yield, composition, live weight gain of cows and calves and feed intake. Pak. J. Biol. Sci., 7: 1523-1525.

Ali, A.I.M., S. Sandi, Muhakka and Riswandi, 2013a. The grazing of pampangan buffaloes at non tidal swamp in south sumatra of Indonesia. Prosiding the 2013 3rd International Conference on Asia Agriculture and Animal (ICAAA2013). 27-28 Juli 2013 di Moscow, Russia (Available online at www.elsivier.com/locate/procedia or www.sciencedirect.com).

Ali, A.I.M., S. Sandi, Muhakka and Riswandi, 2013b. Aplikasi Teknologi Pengelolaan Pakan and Upaya Pemuliaan Kerbau Pampangan Sebagai Plasma Nutfah Sumatera Selatan. Research Report 2013. Ministry of Science and Technology, Republic of Indonesia. http//insentif.ristek.go.id/assets/docs/Direktori_Insinas_2013.pdf.

AOAC, 1995. Official Methods of Analysis. 16th ed. Assoc. Off. Anal. Chem., Arlington, VA.

Bach, A., S. Calsamiglia and M.D. Stern, 2005. Nitrogen metabolism in the rumen. J. Dairy Sci., 88 (E. Suppl): E9-E21.

Biro Pusat Statistik, 2012. Produksi Padi tahun 2011. Jakarta.

Conway, E.J., 1962. Micro diffusion Analysis and Volumetric Error. 5th ed. Crosby Lockwood, London.

Dolezal, P., Jan Dvoracek, J. Dolezal, J. Cermakova, L. Zeman and K. Szwedziak, 2011. Effect of feeding yeast culture on ruminal fermentation and blood indicators of Holstein dairy cows. Acta Vet. Brno, 80: 139-145.

Doyle, P.T., C. Devendra and G.R. Pearce, 1986. Rice straw as a feed for ruminants. IDP, Canberra, Australia.

General Laboratory Prosedures, 1966. Department of Dairy Science. University of Wisconsin, Madison.

Herawaty, R., N. Jamarun, M. Zain, Arnim and R.W.S. Ningrat, 2013. Effect of Supplementation *Sacharonyces cerevisiae* and *Leucaena leucocephala* on low quality roughage feed in beef cattle diet. Pak. J. Nutr., 12: 182-184.

Hungate, R.E., 1969. A Roll tube method for cultivation of strict anaerobe, in method in microbiology (Ed. J.R. Norris and D.W. Ribbons), Academic Press, New York, pp: 313.

Hoover, W.H., 1986. Chemical factors involved in ruminal fiber digestion. J. Dairy Sci., 69: 2755-2766.

Hristov, A.N., G. Varga, T. Cassidy, M. Long, K. Heyler, S.K.R. Kaenati, B. Corl, J. Hovde and I. Yoon, 2010. Effect of *Saccharomyces cerevisiae* fermentation product on ruminal fermentation and nutrient utilization in dairy cows. J. Dairy Sci., 93: 682-692.

Kumar, D.S., Ch. Srinivasa Prasad and R.M.V. Prasad, 2013. Effect of yeast culture (*Saccharomyces cerevisiae*) on ruminal microbial population in buffalo bulls. Buffalo Bull., 32: 116-120.

Lila, Z.A., N. Mohammed, T. Yasui, Y. Kurokawa, S. Kanda and H. Itabashi, 2004. Effects of twin strain of Saccharomyces cerevisiae live cells on mixed ruminal microorganism fermentation *in vitro*. J. Anim. Sci., 82: 1847-1854.

Lynch, H.A. and Martin, S.A. 2002. Effects of Saccharomyces cerevisiae culture and Saccharomyces cerevisiae live cells on *in vitro* mixed ruminal microorganism fermentation. J. Dairy Sci., 85: 2603-2608.

Mao, H.L., H.L. Mao, J.K. Wang, J.X. Liu and I. Yoon, 2013. Effects of *Saccharomyces cerevisiae* fermentation product on *in vitro* fermentation and microbial communities of low-quality forages and mixed diets. J. Anim. Sci., 91: 3291-3298.

Newbold, C.J., R.J. Wallace and F.M. Mcintosh, 1995. Different strains of *Saccharomyces cerevisiae* differ in their effects on ruminal bacterial numbers *in vitro* and in sheep. J. Anim. Sci., 73: 1811-1818.

Ogimoto, K. and S. Imai, 1981. Atlas of Rumen Microbilogy. Japan Scientific Societies Press, Tokyo, pp: 201-221.

Opsi, F., R. Fortina, S. Tassone, R. Bodas and S. Lopez, 2012. Effects of inactivated and live cells of Saccharomyces cerevisiae on *in vitro* ruminal fermentation of diets with different forage: concentrate ratio. J. Agric. Sci., 150: 271-283.

Shiver, B.J., W.H. Hoover, J.P. Sargen, R. Crawford and W.V. Thayne, 1986. Fermentation of high concentrate as affected by rumen pH and digesta flow. J. Dairy Sci., 69: 413-419.

Sung, H.G., Y. Kobayashi, J. Chang, A. Ha, I.H. Hwang and J.K. Ha, 2007. Low ruminal pH reduces dietary fiber digestion via reduced microbial attachment. Asian-Aust. J. Anim. Sci., 20: 200-207.

Tang, S.X., G.O. Tayo, Z.L. Tan, Z.H. Sun, L.X. Shen, C.S. Zhou, W.J. Xiao, G.P. Ren, X.F. Han and S.B. Shen, 2008. Effects of yeast culture and fibrolytic enzyme supplementation on *in vitro* fermentation characteristics of low-quality cereal straws. J. Anim. Sci., 86: 1164-1172.

Tanwar, P.S., Y. Kumar and R.S. Rathore, 2013. Effect of urea molasses mineral block (UMMB) supplementation on milk production in buffaloes under rural management practices. J. Rural and Agric. Res., 13: 19-21.

Tan, Z.L., H.P. Chen and T.X. Xing, 1996. Comparative study on fiber characteristics of rice and wheat straw. Asian-Aust. J. Anim. Sci., 9: 51-56.

Thalib, A., J. Bestari, Y. Widiawati, H. Hamid and D. Suherman, 2000. Effect of rice straw silage treated with rumen microbes of buffalo on digestibility and ecosystem of cattle rumen. J. Ilmu Ternak and Vet., 5: 1-6.

Tilley, J.M. and R.A. Terry, 1963. A two stage technique for *in vitro* digestion of forage crops. J. Br. Grassland Soc., 18: 104-111.

Thu, N.V. and P. Uden, 2000. Effect of work and urea-molasses cake supplementation on live weight and milk yield of murrah buffalo cows. Asian-Aust. J. Anim. Sci., 13: 1329-1336.

Thu, N.V. and P. Uden, 2001. Effect of urea molasses cake supplementation of swamp buffaloes fed rice straw or grasses on rumen environment, feed degradation and intake. Asian Aust. J. Anim. Sci., 14: 631-39.

Tiwari, S.P., U.B. Singh and U.R. Mehra, 1990. Urea molasses mineral blocks as a feed supplement: effect on growth and nutrient utilization in buffalo calves. Anim. Feed Sci. and Technol., 29: 333-341.

Trach, N.X., 1998. The need for improved utilisation of rice straw as feed for ruminants in Vietnam. Livestock Research for Rural Development, 10.

Van Soest, P.J., J.B. Robertson and B.A. Lewis, 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci., 74: 3583-3597.

Vu, D.D., L.X. Cuong, C.A. Dung and P.H. Hai, 1999. Use of urea-molasses-multinutrient block and urea-treated rice straw for improving dairy cattle productivity in Vietnam. Prev. Vet. Med., 38: 187-193.

Wanapat, M., A. Petlum and O. Pimpa, 1999. Strategic supplementation with a high quality feed block on roughage intake, milk yield and composition and economic return in lactating dairy cows. Asian-Aust. J. Anim. Sci., 12: 901-903.

Wallace, R.J. and C.J. Newbold, 1992. Probiotics for ruminants, Pages 317-353 in R. Fuller, ed. Probiotics: the scientific basis. Chapman and H all, London, UK.

Yoon, I.K. and M.D. Stern, 1996. Effects of *Saccharomyces cerevisiae* and *Aspergillus oryzae* cultures on ruminal fermentation in dairy cows. J. Dairy Sci., 79: 411-417.

Zain, M., Arnim, R.W.S. Ningrat and R. Herawati, 2011. Effect of yeast (*Saccharomyces cerevisiae*) on fermentability, microbial population and digestibility low quality roughage (*in vitro*). Arch. Zootecnica, 14: 4-11.