IN VITRO DIGESTIBILITY OF RICE STRAW AFTER MUSHROOM CULTIVATION AND THE UTILIZATION OF NUTRIENTS OF ENRICHED RICE STRAW BY RED SINDHI CROSSBRED CATTLE

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ABSTRACT

Two experiments were carried out from Feb to Aug, 2017 at the laboratory and the experimental farm of Can Tho University to investigate nutrient contents and *in vitro* digestibility values of rice straw after it's use to cultivate mushrooms and to evaluate the effect of rice straw enriched by urea, molasses and minerals on *in vivo* digestibility and nutrient intake of cattle. In Experiment 1 a complete randomised design was used for the *in sacco* evaluation of rice straw at three stages: initial (R), at 20 days treated with water (RW20) and after harvesting mushrooms (MS). There were 8 replicates of each treatment. Faeces of a Murrah buffalo were used as inoculant. In Experiment 2, four Red Sindhi crossbred cattle (138 ± 12 kg) were allocated in a 4 x 4 Latin Square design to four diets, which included rice straw (R), rice straw plus urea-molasses-mineral mixture (RS+UMM), urea-treated rice straw (URS) and urea-treated rice straw plus molasses-mineral mixture (URS+MM). The crude protein and ash in MS was higher and NDF lower than in R and RW20. *In vitro* digestibility values at 24 h were similar but were lower for MS at 96 h.The MS after drying was dark, dusty and had a bad smell and was not palatable to cattle. In Experiment 2, adding urea, molasses and minerals to rice straw, or molasses and minerals to urea-treated rice straw, increased intake, DM *in vivo* digestibility and N retention.

Keywords: *Cattle, rice straw, mushrooms, digestibility, intake*

INTRODUCTION

The Mekong delta of Vietnam is the main rice bowl of the country, thus a large amount of rice straw is produced. Some is used for feeding ruminants, some is burned and the ash used as fertilizer, and a part of it is used for cultivation of mushrooms. The rice straw after harvesting the mushrooms is normally used as fertilizer. It was reported that white rot fungi (*Actinomycetes*) were able to biodegrade lignin and ligno-cellulose. From this arose the idea that growing mushrooms on rice straw might improve its nutrient value for feeding to ruminants. Nguyen Van Thu (2019) concluded that adding urea, molasses and minerals to rice straw increased the nutrient content and the *in vitro* digestibility and Lipi et al. (2018) also stated that ensiling wet rice straw with up to 10% biogas slurry and 5% molasses significantly improves the nutritional values of ensilage and may be a feasible means of preserving and converting slurry. Thus an approach to improving rice straw quality is to supplement it with molasses, urea and minerals (Thu and Udén, 2000 and Nguyen Van Thu, 2019). This study, therefore, aimed to investigate: (i) the nutrient content and *in vitro* digestibility values of the residue from straw used to grow mushroom; and (ii) and effect of supplementing rice straw with urea, molasses and minerals for further studies and applications.

MATERIALS AND METHODS

Experimental design and methods

Two experiments were carried out from Feb to Aug, 2017 at the laboratory and the experimental farm of Can Tho University. In Exp 1, a complete randomized design was used to evaluate the nutritive value of rice straw used for growing mushrooms. Samples for analysis and in vitro digestibility were taken at the initial stage (R), at 20 days after treatment with water (RW20) and after harvesting the mushroom (MS). There were eight replicates (batches of straw used for growing the mushrooms). Samples were analysed for DM, N and NDF by AOAC (1990) procedures and used to measure organic matter degradability by the *in vitro* method using faeces from buffaloes fed natural grasses as inoculant (Nguyen Van Thu and Udén, 2003).

In the Exp 2 four Lai Sind cattle (138 ± 12kg) were allocated in a 4 x 4 Latin Square design with four diets: rice straw (RS), rice straw with added urea-molasses-mineral mixture (RS+UMM), urea-treated rice straw (URS) and urea-treated rice straw plus molasses-mineral mixture (URS+MM). Each experimental period was three weeks, including one week for adaptation. Feeds were offered twice a day at 7:15 and 14:15h. Feeds offered and refusals were collected daily and pooled weekly for analysis of DM to calculate feed intake. *In vivo* DM, OM and NDF digestibility values were estimated by total faecal collection for 7 d beginning 2 d after the start of feed intake recording (McDonald et al., 2002). Rice straw was treated with 5% urea (100 kg straw, 5 kg urea, 100 kg water), and it was fed to experimental animal safter 21 days of storage. Rice straw in the RS diet before feeding was added water to make it softer (36.8% water based on fresh matter basis). The RS+UMM diet included 1.2% urea, 10.6% molasses and minerals. For the URS+MM diet, 12.7% molasses and minerals were added 24hr before feeding.

Chemical analysis

In both experiments feed samples were dried at 105^{o}C over night to determine dry matter (DM). The OM was determined by ashing samples in a furnace at 500^{o}C for 4 h. The crude protein was determined by the Kjeldahl method (AOAC, 1980). Analysis of neutral detergent fiber (NDF) was by a method described by Van Soest et al. (1991). Acid detergent fiber (ADF) was analyzed by the method suggested by Robertson and Van Soest (1981). Feeds offered and refusals were collected daily and pooled weekly for analysis of DM to calculate feed intake.

Statistical analysis

In Exp 1, the data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of Minitab (2010). When the F test was significant (P<0.05), Tukey's test for paired comparisons was used.

The data from *in vitro* degradability were fitted to a non-linear model (Ørskov et al., 1980):

$DMD = a + b\,(1 - e^{-ct})$,

where DMD = DM disappeared after time (t), a = the intercept on the "y" axis, c= fractional degradation rate (h^{-1}) and a+b = the curve asymptote representing the potential degradability. The Table Curve 2D V4 program (Table Curve 3D V4, 2007) was used for curve fitting.

In Experiment 2 data were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of Minitab release 16.1.0 (2016). Then Tukey's test for paired comparisons was used.

RESULTS AND DISCUSSION

Experiment 1

The cultivation of mushrooms reduced the organic matter and NDF content of the straw but increased the crude protein content (Table 1).

Table 1. Changes in composition of rice straw during the cultivation of mushrooms (on DM basis except for DM which is as % of fresh matter)

	Initial	**After 20 day**	**After harvesting mushrooms**	**Prob.**
DM	91.8^a	24.8^b	23.5^b	0.001
OM	86.7^a	86.6^a	80.2^b	0.01
CP	6.30^a	6.93^a	9.23^b	0.001
NDF	56.8^a	57.3^a	43.8^b	0.01
ADF	42.2	42.8	45.7	0.01
Ash	13.3^a	13.4^a	19.8^b	0.01

Note: ^{ab} Means without letter in common are different at P<0.05

The OM degradability of the straw after mushroom cultivation was reduced after 96h of incubation (Table 2) with no apparent changes at earlier times. After drying the final product it was dark in colour, dusty and had a bad smell. When it was offered to cattle they ate very little. There appeared to be no relationship between the degradation parameters "a", "b" and "c" and the measured degradability values. No changes in degradability are to be expected due to addition of water to the straw, and this was the case according to the degradation values even at 96h, yet the "b" values were 30% less for this treatment according to the fitted curve parameter. Also the "c" value was higher for the residue after mushroom growing, than for the original straw, which is also in conflict with the observed values for OM loss and 96h degradability.

Table 2. *In vitro* OM digestibility values (%) of rice straw during cultivation of mushrooms

Incubation time, h	**Initial**	**After 20 days**	**After harvest**	**Prob.**
0	22.2	22.1	24.2	ns
12	31.8	27.9	32.6	ns
24	34.2	33.2	37.3	ns
48	41.2	44.8	40.7	ns
72	44.6	47.0	44.1	ns
96	55.0^a	55.0^a	48.7^b	0.01
Parameters of degradation curve				
a	24.4	21.9	25.1	
b	60.0	46.6	24.1	
a + b	84.4	68.5	49.2	
c	0.0068	0.0123	0.0259	

Note: ^{ab} Means without letter in common are different at P<0.05

The effects of supplementation on the composition of the diets in Experiment 2 are in line with the nature of the treatments (Table 3).

Experiment 2

Table 3. Composition of rice straw and supplemented rice straw in Experiment 2 (on DM basis except for DM which is as % of fresh matter)

	RS	RS+UMM	URS	URS+MM
DM	57.7	60.5	64.0	65.9
OM	83.9	84.7	83.7	84.3
CP	7.43	12.5	11.3	11.2
NDF	49.4	41.2	48.8	41.2
ADF	50.9	49.4	57.5	59.3
Ash	16.1	15.3	16.4	15.6

Note: Rice straw (R), rice straw plus urea-molasses-mineral mixture (RS+UMM), urea-treated rice straw (URS) and urea-treated rice straw plus molasses-mineral mixture (URS+MM)

The rice straw intake was increased by supplementation with molasses / minerals and by treatment with urea (Table 4), with highest values for the urea-treated straw supplemented with molasses and minerals. The high intake of crude protein on this latter diet was due to the increased DM intake,m as both diets had the same concentration of crude protein (Table 3).

Table 4. Intake of rice straw, water, and crude protein and urine production of young cattle in Experiment 2.

	RS	RS+UMM	URS	URS+MM	Prob.
Rice straw (kg DM/day)	2.22^{a}	3.03^{b}	3.0^{b}	3.71^{c}	0.001
Rice straw (g/kg LW/day)	15.2^{a}	20.5^{b}	20.7^{b}	25.3^{c}	0.05
Drinking water (kg/day)	8.5^{a}	11.5^{c}	10.2^{b}	11.1^{b}	0.001
Urine (kg/day)	3.2	3.3	3.4	3.5	ns
Crude protein (g/day)	162^{a}	381^{c}	341^{b}	417^{d}	0.001

Note: ^{ab}Means without letter in common are different at P<0.05

DM and OM digestibility were higher (P<0.05) for all supplementation treatments compared with untreated rice straw but the improvement was only significant for urea-treated rice straw plus molasses / minerals (Table 5). NDF digestibility was higher for the two treatments with urea-treated rice straw compared with untreated straw. Nitrogen retention was increased by molasses / minerals supplementation with and without urea treatment (P<0.05). Urea treatment of the straws, and supplementation with urea-molasses-minerals, led to improvements in *in vitro* OM digestibility (Nguyen Van Thu, 2019). These results are similar to those reported by Chowdhury and Huges (1998) for addition of urea-molasses to rice straw.

Table 5. *In vivo* digestibility coefficients (%) for DM, OM and NDF and nitrogen retention of young cattle in Experiment 2

	RS	RS+UMM	URS	URS+MM	Prob.
DM	43.2[a]	47.8[ab]	53.4[ab]	57.0[b]	0.05
OM	39.9[a]	43.6[ab]	48.8[ab]	51.3[b]	0.05
NDF	55.5[ab]	50.9[a]	68.5[c]	63.8[bc]	0.01
N retention (% of N intake	9.45[a]	42.0[b]	39.6[b]	43.7[b]	0.05

Note: [abc] Means without letter in common are different at P<0.05

The lack of difference in N retention between urea-supplemented (untreated) rice straw and urea-treated rice straw, when molasses / minerals were also fed, emphasis the importance of testing the two strategies in feeding trials to measure animal performance traits, since it is more economical and simpler to supplement the straw with urea than to "treat" it with urea.

CONCLUSION

It appears that the residue from rice straw after mushroom cultivation is of lower nutritive value (contains around 50% more ash) than the original straw and is likely to be of negligible feeding value for cattle. Addition of molasses and minerals to untreated rice straw supported the same N retention in cattle as when these supplements were added to urea-treated rice straw. There is a need to test the two strategies (molasses/minerals/urea supplementation of rice straw versus molasses/minerals supplementation of urea-treated rice straw) in feeding trials with growing cattle.

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