EFFECTS OF TREATMENT OF FRESH RICE STRAW ON ITS NUTRITIONAL CHARACTERISTICS

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ABSTRACT

Treatment of fresh rice straw right after harvesting was tried as an effort for preservation together with improvement of its feeding value for better utilization as roughage. Fresh straw was ensiled with either urea (1, 1.5, and 2% w/w) or molasses (1, 2, and 3% w/w) in small silos for different lengths of time (30, 60, and 90 days). Evaluation was made based on color, mold, smell, pH, chemical composition (DM, CP, ADF, NDF, ADL, ash) as well as *in-sacco* degradation characteristics (A, B, c, and L). It was found that making silage of fresh straw without addition of molasses resulted in extensive mold development and could not reduce pH low enough for good preservation (pH>4.9). Addition of 3% molasses reduced pH low enough (<4.2) for effective preservation of straw with good color and smell; however, an upper part of straw silage was still molded. However, urea treatment allowed to preserve fresh straw without either molding or organic matter loss. Urea treatment highly increased pH (>8), dramatically increased crude protein, significantly reduced NDF with improved *in-sacco* degradability of straw. The higher the level of urea was applied the better the effect was found. It is therefore recommended that fresh rice straw be treated with 1.5-2% urea for long-term preservation and improving its feeding value.

Key words: Fresh rice straw, chemical composition, pH, *in-sacco* degradability

1. INTRODUCTION

Cattle in Vietnam are underfed during the winter-spring period while rice straw is abundant (Nguyen Xuan Trach, 1998). Because rice straw is voluminous it is costly for farmers to transport and store and difficult for cattle to consume enough nutrients. Although numerous methods of treatment have been developed to improve the feeding value of rice straw (Schiere and Ibrahim, 1989; Wanapat and Devendra, 1985**)**, the level of practical application by farmers has been limited (Devendra, 1997). One of the reasons is that the techniques which have been developed are for dry straw treatment. That is, the farmer has to dry straw and store it for a long time before treatment. This is inconvenient for farmers because: (1) It is time and labor consuming while the farmer is too busy with rice harvesting, (2) It is too much subjected to weather conditions, (3) It requires much space for straw drying and storing in addition to the space needed for treatment (silo), and (4) It causes much loss of nutrients during the drying process. Consequently, while cattle are in shortage of forage, vast amounts of rice straw are left or burnt in the field. If there is a method to preserve and/or treat fresh straw (FRS) right after harvesting, it would be more convenient for farmers to apply in practice.

Research into treatment of FRS as feed has been limited so far. In Vietnam, recently

Duong Nguyen Khang and Viktorrsson (2004) used FRS treated with 4% urea as the basal diet for their studies on effects of using cassava foliage as a protein source for cattle feeding. Le Thi Thuy Hang et al. (2007a, b) have also used FRS treated with urea plus lime to partially substitute para grass or immature maize stover in cattle diets. However, the authors took the alkali treatments for granted to apply for FRS without looking in detail at the effects of treatment on the quality of straw. It is therefore hypothesized for the present study that FRS can be delignified for improved degradability and preserved for a long time by means of urea treatment which produces ammonia during ensilage. On the other hand, it is also hypothesized that FRS can be ensiled for the purpose of long term preservation by adding enough fermentable carbohydrates which should help to lower pH of the ensiled straw.

2. MATERIALS AND METHODS

Fresh rice straw was ensiled in small plastic silos (2 liter/silo) either with molasses (silage making) at 0, 1, 2, and 3% or with urea (alkali treatment) at 1, 1.5, and 2% on a fresh matter basis (w/w). After paddy threshing straw was collected and chopped into 3-5cm long pieces and well mixed with the additives before pressing into the silo until it was full. The silo was then sealed air-tight. Each treatment was made in triplicate and kept for 30, 60 or 90 days before opening for quality evaluation.

After opening the silo the straw was first assessed in terms of color and smell. Mold growth was graded based on the molded proportion of the straw sample.

The method proposed by Hartley and Jones (1978) was applied for determining of pH of straw. Samples of 5g each were milled into 1-2mm pieces and well stired in 100ml distilled water. The mix was left for 15 minutes and then pH was measured with a pH meter.

Straw samples were analyzed for dry matter (DM) and nitrogen (N) following the Official Methods of AOAC (Cunniff, 1997). In addition, neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were determined according to Van Soest and Robertson (1985).

The nylon bag technique was used to determine degradation characteristics of the dry matter (DM) of the untreated and treated straws incubated together in the rumen of 3 fistulae Yellow oxen fed on a fixed diet consisting of 50% medium hay and 50% green grass given at a maintenance level. The nylon bag technique as described by Ørskov *et al*. (1980) was applied for determination of DM loss. Air-dried substrate samples were ground to pass a 2.5 mm sieve. *In-sacco* samples of 3 g each were then taken into nylon bags in duplicates. The pore size of the nylon bags was 37 µm and the inner size of the bag was 6 cm x 12 cm. The bags were incubated starting one hour after the cattle were offered the morning meal. The incubation times were 4, 8, 16, 24, 48, 72, and 96 hours. After incubation, the bags with residues were taken out of the rumen, dipped immediately into cold water to stop microbial activity, then rinsed by cold tap water to remove the rumen matter from the outside of the bags. Thereafter, the bags with contents were rinsed with cold water for 30 minutes in a washing machine. Finally, they were dried at 60^{o}C for 48 hours. To determine the contents of water-soluble fraction, two sample bags of each straw type were soaked

in a water bath for 24 hours and then underwent the same washing and drying procedures as the incubated bags. Duplicate bags of each sample were similarly dried for determination of the DM content of the samples for calculation of DM disappearance. The Neway Excel program (Chen, 1997) was used for the computation of degradation parameters as described by Orskov and Ryle (1990): water soluble fraction (A), fermentable insoluble fraction (B), potential degradability (A+B), degradation rate constant (c), and lag phase (L).

Experimental data were subjected to analysis of variance (ANOVA) using the GLM Proc. of MINITAB12 (1998). Pair wise comparisons of means were made using the Tukey method.

3. RESULTS AND DISCUSSION

Effects of silage making and urea treatment of straw on color, smell, and mold growth are presented in Table 1. The straw samples ensiled without additives showed blackish brown color, while those samples ensiled with molasses became yellow. The straw samples ensiled without molasses had an unpleasant smell with heavy mold. The samples ensiled with molasses were still molded at different levels, but the moldless parts had a fragrant smell of a fermented product. Differently, all the urea treated samples had a brown color with a pungent smell and no sign of mold, indicating the effect of ammoniation (Sundstol and Coxworth, 1984). The higher the level of urea was applied the stronger the pungent smell was found to be.

Table 1. Effects of treatment on color, smell and molding of rice straw.

	Straw treatment	Color	Smell	Mold
Silage making	No additive	Black-brown	Unpleasant	+++
	1% molasses	Yellowish	Slightly acidulous	+
	2% molasses	Yellow	Fragrant acidulous	+
	3% molasses	Yellow	Fragrant acidulous	+
Alkali treatment	1% urea	Brown	Slightly pungent	nil
	1.5% urea	Brown	Pungent	nil
	2% urea	Brown	Strongly pungent	nil

N.B.: Nil: no mold, + slightly molded, +++ Heavily molded.

Table 2 shows that making silage of FRS with molasses reduced its pH. The higher the level of molasses was applied the lower the pH value was found to be. The pH value of FRS ensiled without molasses was much higher, indicating that in FRS the sugar content was not enough for lactic fermentation to lower pH to a needed level. Use of 3% molasses reduced straw pH down to a level low enough (<4.2) for its long term preservation as silage. On the other hand, urea treatment increased pH of straw to high value (> 8), which is needed for straw delignification (Sundstol and Coxworth, 1984). The higher the level of urea was applied the higher the pH value became.

Table 2. Effect of different treatments on straw pH

	Straw treatment	pH		
		30 days	60 days	90 days
	Untreated FRS	6,02[c]	6,02[d]	6,02[c]
Silage making	No additive	4,91[d]	4,99[e]	5,06[d]
Silage making	1% molasses	4,47[e]	4,42[g]	4,43[g]
Silage making	2% molasses	4,28[g]	4,20[h]	4,23[h]
Silage making	3% molasses	4,05[h]	4,18[h]	4,13[i]
Alkali treatment	1% urea	8,01[b]	8,13[c]	8,24[b]
Alkali treatment	1.5% urea	8,51[a]	8,46[b]	8,74[a]
Alkali treatment	2% urea	8,60[a]	8,77[a]	8,86[a]
	SEM	0.24	0.21	0.20

N.B.: Means in the same column that bear different superscripts are statistically different at P< 0.05.

Table 3. Chemical composition of straw subjected to different treatments

	Straw treatment	DM (%)	Chemical composition (%DM)			
			CP	NDF	ADF	ADL
	Untreated straw	26.33	7.37[a]	69.03[a]	35.74	4.29
Silage making	No additive	26.29	7.61[a]	67.90[a]	36.03	4.72
Silage making	1% molasses	25.51	7.79[a]	67.89[ab]	36.56	4.63
Silage making	2% molasses	26.13	7.76[a]	68.09[a]	34.40	4.33
Silage making	3% molasses	27.56	7.90[a]	67.36[a]	35.50	4.16
Alkali treatment	1% urea	25.67	9.04[b]	66.28[ab]	35.14	4.07
Alkali treatment	1.5% urea	28.07	9.25[b]	64.17[b]	34.16	4.83
Alkali treatment	2% urea	28.06	9.34[b]	63.20[b]	35.04	4.58
	SEM	1.23	0.37	1.48	0.87	0.33

N.B.: Means in the same column that bear different superscripts are statistically different at P< 0.05.

Table 3 shows the chemical composition of FRS as affected by silage making and urea treatment. Silage making did not significantly affect crude protein (CP) and cell wall components (NDF, ADF, ADL) of straw. However, urea treatment highly increased CP (P<0.001) and reduced NDF (P<0.05), but did not significantly affect the other cell wall components (ADF and ADL) as compared with untreated straw. The effects of urea treatment of FRS on its chemical composition were similar to those previously found for urea treatment of dry rice straw (Nguyen Xuan Trach, 2000).

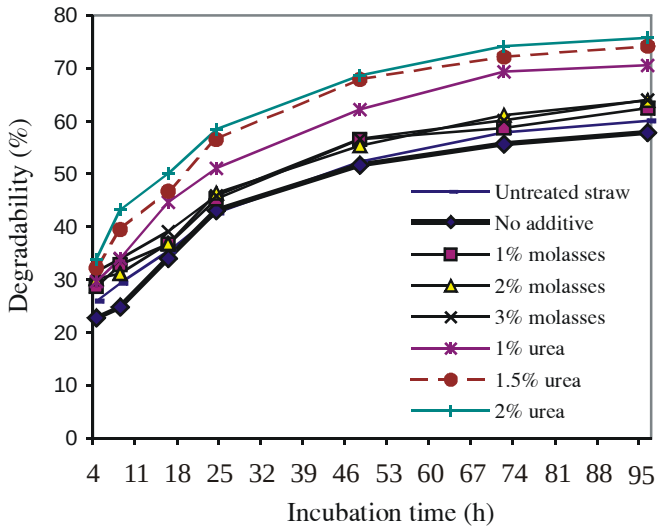

Figure 1. *In-sacco* degradability of straw DM subjected to different treatments

Figure 1 shows *in-sacco* degradability of straw DM subjected to different treatments after different incubation times. In addition, Table 4 shows degradation characteristics of the straw DM. As can be seen, silage making did not significantly increase straw DM *in-sacco* degradability, whereas urea treatment significantly improved its degradation characteristics.

Table 4. Degradation characteristics of straw subjected to different treatments

Straw treatment		Water-soluble fraction (A, %)	Fermentable Insoluble fraction (B, %)	Potential degradability (A+B,%)	Degradation rate (c, %/h)	Lag phase (L, h)
Untreated straw		23.5^{b}	39.6^{a}	62.1^{a}	0.033^{a}	2.6^{a}
Silage making	No additive	17.9^{a}	41.6^{a}	59.5^{a}	0.034^{a}	2.3^{a}
	1% molasses	23.0^{b}	41.2^{a}	64.2^{a}	0.035^{a}	2.4^{a}
	2% molasses	$25,0^{bc}$	40.7^{a}	65.7^{a}	0.036^{ab}	2.2^{a}
	3% molasses	27.7^{c}	40.2^{a}	67.9^{ab}	0.036^{ab}	2.3^{a}
Alkali treatment	1% urea	25.5^{bc}	46.9^{b}	72.4^{b}	0.039^{bc}	2.1^{a}
	1.5% urea	28.5^{cd}	47.7^{b}	76.2^{bc}	0.041^{c}	1.5^{b}
	2% urea	31.3^{d}	47.4^{b}	78.7^{c}	0.040^{c}	1.2^{b}
SEM		1.9	2.3	2.6	0.002	0.25

N.B.: Means in the same column that bear different superscripts are statistically different at $P< 0.05$.

Straw ensiled without molasses had a very low soluble faction (A), lower than that of untreated straw. It is possible that some soluble substances in fresh straw had been fermented during silage making. Addition of molasses tended to increase the soluble fraction (A) of the product and thus straw degradability at early incubation times. However, the potential degradability (A+B) was not significantly increased by adding molasses. That was mainly because the fermentable insoluble fraction (B) was not increased by silage making. However, all urea treatments (1%, 1.5%, and 2%) brought about significant increases in all the values of water solubility (A), insoluble but degradable fraction (B), the potentially degradable proportion (A+B), and the rate constant (c), compared to untreated straw and straw silage. The lag phase (L) was effectively reduced by urea treatment ($P<0.05$). The dose responses were almost linear with higher responses to the increasing levels of urea applied.

The above results from the present study indicate that FRS cannot be made silage without addition of an easily fermentable like molasses. In this case, straw becomes molded and pH is not lowered to a level safe enough (<4.2) for long term preservation of it as silage. Use of molasses as an additive to FRS before ensiling could help reduce pH to a lower level, but there still existed the problem of mold. This should result in loss of organic matter and reduced palatability of straw. Even when molasses was added, degradation characteristics of the silage made was not clearly improved. Therefore, FRS should not be recommended for silage making.

In contrast, urea treatment brought about three improvements for FRS. *First*, the treated straw was free of mold as results of anti-molding effect of ammonia released during treatment (Fradhan *et al.*, 1997), which would allow for using urea for long-term preservation of FRS. *Second*, urea treatment of FRS resulted in an increase in its CP content, which would be needed for effective growth of rumen microbes as the level of CP in the original straw was too low (7.37% DM). *Third*, although the changes in the cell wall components may not give much information on the feeding quality of straw **(**Sundstol and Coxworth, 1984), the improvements in *in-sacco* degradation characteristics of straw DM clearly indicated a positive effect of urea treatment of FRS on its cell wall delignification, which would allow for better attack of rumen microbes to straw cell walls. The present results provide an underlying support for conclusions made from recent feeding trials in South Vietnam that fresh rice straw treated with urea plus lime (alkali treatment) can partially replace immature maize stover in diets of fattening cattle (Le Thi Thuy Hang *et al.*,2007a) or para grass in lactating cow diets (Le Thi Thuy Hang *et al.*, 2007b).

Based on the findings from the present study, treatment of FRS with 1.5-2% urea (4-5% on a DM basis) should be recommended for long term preservation of rice straw and improvement of its nutritive value for ruminant feeding.

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