EFFECT OF UREA ON WET RICE STRAW FOR PRESERVING ITS KEEPING QUALITY AND NUTRITIVE VALUE IN CATTLE DIETS

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Summary

About 8 million tons of straw (dry matter) become rotten during the monsoon (June to August) season in Bangladesh. The possibility of preserving straw with urea, under wet condition during dry period (December to May) and its utilization by cattle has been studied. Five tons of fresh and wet (600 g DM/kg material) rice straw were preserved for six months, with 5% urea (W/W) in either dome or rectangular shaped heap without any polythene cover. The preservation quality, acceptability and nutritive value of preserved straw were then compared with that of dry straw in growing cattle. In both types of heaps, straw was excellently preserved having strong ammonia smell, dark brown in colour with no fungal infestation. Urea preservation of straw increased its CP and ADF content. Preserved straw was readily accepted by the animals and they were healthy throughout the experimental period. Compared to dry straw, urea preserved straw had nonsignificantly higher rumen degradability, straw intake and growth rate. Similarly, digestibilities of DM ($p < 0.01$), OM ($p < 0.01$) & ADF ($p < 0.01$) were significantly higher in the preserved than the dry straw. It was concluded that wet straw with relatively lower moisture (400 to 500 g/kg straw) content can be readily preserved by using urea without being covered with polythene. Whether the same phenomenon occurs in the preservation of fresh and wet rice straw with relatively higher moisture (600 to 700 g/kg straw) content is yet to be determined.
(**Key Words** : Wet Straw, Preservation, Urea, Nutritive Value)

Introduction

Farmers in Bangladesh usually store rice straw in heaps after sun drying. However, due to heavy rain fall (337 mm) and high humidity (86%), they cannot dry their straw during monsoon (June to August). As a result, about 8 million tons of straw dry matter (DM) from Boro and Aus crop are usually rotten (Chowdhury and Huque, 1995). Work in this laboratory (Chowdhury and Huque, 1995) has shown that wet straw can be preserved for as long as 180 days by ensiling it with 5% (W/W) urea in sealed plastic container. If wet straw can be preserved with urea in heaps it will: i) save straw from being rotten; ii) improve the nutritive value of straw and iii) save farmers labour and time.

Urea treatment increases the rate and extent of degradation of straw by providing more digestible cellulose, hemicellulose and N to the rumen microbes (Silva and Ørskov, 1988a). Preservation of wet straw with urea increases the rate and extent of fibre degradation (Chowdhury and Huque, 1995). Earlier work (Mold and Orskov, 1984; Mould et al., 1983; Silva and Ørskov, 1984) demonstrated that manipulation of rumen environment by different type and level of supplements had effect on rumen activity. Fish meal has been reported to have positive effect on fibre degradation and growth rate (Saadullah 1984; Silva and Ørskov 1988b).

The present work was thus designed to :

i) determine the keeping quality of wet straw preserved with urea; and

ii) study the influence of feeding dry straw or urea preserved wet straw supplemented with fish meal on growing bulls.

Materials and Methods

Straw Preservation

Five tons of fresh and wet (600 g DM/kg material) rice straw was preserved with 50 g urea/kg straw DM either in dome or rectangular shaped heap. Stacks were

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Received June 29, 1995
Accepted October 7, 1995

built by spreading straw in layers, each containing 40 kg straw and 1.2 kg urea. Straw was preserved for six months from December, 1993 to may 1994.

Preservation quality

After 180 days of preservation, straw was checked for temperature, colour, smell and presence of any fungal infestation. Samples were taken for chemical analysis and *in sacco* dry matter degradability.

Feeding trial

Eight indigenous growing bulls of approximately 30 months old and 223 kg initial live weight were used for a 97 d feeding trial. At the onset of the trial, animals were treated with anthelmintics and overnight fasted weights were recorded as their initial live weights. They were housed and fed individually and measured amounts of feed were given twice daily. Residual feed were measured in the next day morning.

Experimental treatment

Eight growing bulls were randomly divided into two groups, having four animals in each. They were given 1.5 kg wheat bran and 100 g fish meal daily. Half of the animals received dry straw (DS) and the rest received urea preserved straw (PS) *ad libitum*.

Rumen degradation characteristics

Three bulls fitted with rumen cannula of 40 mm diameter, were used. Nylon bags containing 1 g of air dry sample were anchored to a 30 cm plastic tube and withdrawn from the rumen at 8, 16, 24, 48 and 72 hours of incubation. Dry matter losses were determined for each incubation period and data for each type of straw was described by the exponential equation of McDonald (1981), $p = a + b(1 - e^{-ct})$, where p is degradation in time t and a, b and c are constants. Constant 'a' represents the intercept, 'b' is the insoluble but degradable material and 'c' is the rate constant of b. It follows that (a + b) is the potential degradability of straw and is a measure of its nutritive value. In some instances, as we will see later, 'a' could be negative, indicating a lag phase. This will results in an elevated 'b' value but the (a + b) will represents the total potential.

Digestibility

From the 90th day of the feeding trial, digestibility of the two rations were measured for 7 days. During this period, in addition to the usual record of feed offered and residue left, 24 hours faeces production of the individual animal was also recorded. Digestibility of the individual nutrients was measured from its intake.

Live weight gain

The animals were weighed fortnightly before being fed in the morning till the end of the experiment. Daily gain was calculated as the slope of the individual regression of live weight vs. time.

Chemical analysis

Samples of feed ingredients, refusals and faeces were analysed for dry matter, organic matter and crude protein (N × 6.25) and acid detergent fibre according to AOAC (1984).

Statistical analysis

A simple t test was used for measuring the differences of means of each variate with appropriate standard error of mean difference (SED). Simple linear regression of the form $y = a + bx$ was used for measuring the slope between two variables where appropriate.

Results and Discussion

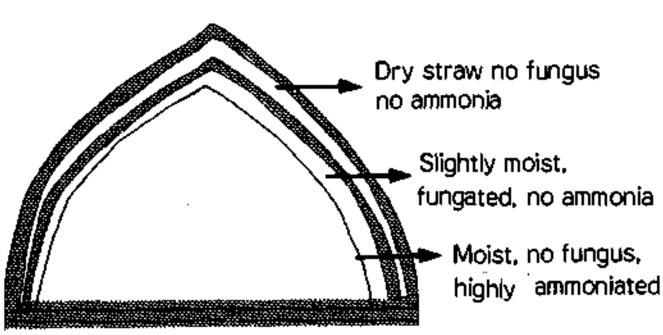

Fig. 1 a.

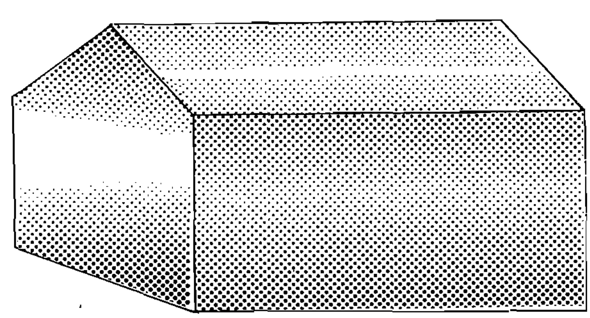

Fig. 1 b.

Figure 1. Wet straw (600 g DM / kg straw) preserved (with 50 g Urea / kg dry matter) either in dome (a) or rectangular (b) heap.

According to straw qualities both rectangular and dome shaped heap can be divided into three parts (see figure 1), peripheral part (about 10 cm), middle part (about 25 cm) and central part (about 180 cm). As was expected, due to dircet exposure to open air, straw in the peripheral part was relatively dry (158 g moisture per kg straw), grey in colour without any ammonia smell. While straw in the middle part, was relatively moist (248 g H_2O/kg straw), with no ammonia smell resulting in the fungal infestation. The central part which comprises approximately 90% of the total preserved straw, was moist (468 g H_2O/kg straw), dark brown in colour with strong ammonia smell and was preserved excellently. Chowdhury and Huque (1995) showed that in preserving straw with urea under wet condition, the liberated ammonia (from urea) must be entrapped properly. Excellent preservation quality of wet straw in the present trial, may indicate that the natural sealing (due to gravitational force) of the heap was enough to entrap the required level of ammonia for the preservation process. This may suggest that, wet straw with relatively lower moisture content (400 to 500 g/kg straw), can be readily preserved by using urea without being covered with polythene.

Table 1 shows the chemical composition of preserved straw at different parts of the heap. As were expected, the moisture content increased while the CP and the ADF content decreased from the inner towards the peripheral parts of the heap. Ammonia generated from the hydrolysis of urea, was better trapped inside the heap than towards the periphery. Increased CP and ADF contents due to urea preservation has also been observed in earlier works in our laboratory (Chowdhury and Huque, 1995) when ammonia is being trapped properly. Higher ADF content

TABLE 1. CHEMICAL COMPOSITION OF PRESERVED STRAW AT DIFFERENT PARTS OF THE HEAP

	Surface layer	Middle layer	Central alyer
Dry matter (g/kg fresh matter)	842	752	532
Organic matter (g/kg DM)	887	858	860
Crude protein (g/kg DM)	68	75	104
ADF (g/kg DM)	474	502	523

was probably due to solubulization of cell solubles (Tetlow, 1983). Urea (ammonia) treatment increases the acid detergent insoluble N (ADIN) content of straw (Singh and Negi, 1985) which may also impart be responsible for the observed higher ADF content in the preserved straw.

In both dome shaped and rectangular heaps, there was no marked difference between the ambient temperature (27℃) and the temperature inside the heap (28℃). This is similar to our earlier (Chowdhury and Huque, 1995) observation that wet straw preserved under alkaline condition (pH > 8) there is no rise in temperature. This is probably due to lower moisture and fermentable sugar content in the straw preserved. However, soluble sugar content of straw depends on type cultivar, intercultural practices, environmental conditions (e.g. drought, flooding, etc.), harvesting condition, post harvesting treatment of straw and post harvesting preservation period (Perdock and Leng, 1987), all these factors might affect the quality of preserved straw.

Chemical composition of feed ingredients

The chemical composition of dry straw, preserved straw, wheat bran and fish meal are given in table 2. Urea preservation increased the CP content from 68 to 104 g/kg DM. This 47% increase in CP content is less than that observed (176%) in wet straw preserved with 5% urea in sealed container (Chowdhury and Huque, 1995). This is probably due to the loss of some of the ammonia from the pit as there was no polythene cover to entrap the liberated ammonia. The crude protein content of fish meal (419 g/kg) was very low in the present trial compared normal reported values (600 g/kg) which indicate its lower quality.

TABLE 2. CHEMICAL COMPOSITION OF THE FEED INGREDIENTS USED IN THE TRIAL

	Dry matter (g/kg)	g/kg Dry matter		
		Organic matter	Crude protein	ADF
Dry straw	812	886	68	474
Preserved straw	710	858	104	523
Wheat bran	901	944	202	207
Fish meal	899	657	419	100

Degradability

Degradation characteristics of preserved and dry straw at different hours of incubation are presented in table 3. Urea preservation significantly ($p < 0.01$, except at 72 h) increased the straw DM degradability at all hours of incubation. This confirms our previous observation (Chowdhury & Huque, 1995) that preservation of wet straw increases the DM degradability in the rumen. The

TABLE 3. DEGRADATION OF STRAW DRY MATTER AT DIFFERENT HOURS OF INCUBATION IN THE RUMEN OF CATTLE TOGETHER WITH THE CONSTANTS OF THE EQUATION : $p = a + b(1 - e^{-ct})$

Hours of incubation	Dry straw	Preserved straw	SED	Significance
8	7	30	13.4	$p < 0.01$
16	17	34	1.66	$p < 0.01$
24	22	40	2.24	$p < 0.01$
48	41	54	2.51	$p < 0.01$
72	43	56	5.78	NS
a	−6.7	20.5	–	–
b	56.0	42.8	–	–
c (%)	3.35	2.70	–	–
RSD	2.79	2.42	–	–
(a + b)	49.3	63.3	–	–

48 h DM degradability for the dry and preserved straw were 41 and 54% respectively. This increase (13%) in straw DM degradability due to urea preservation was much higher in the present case than the increase (5%) observed in barley straw treated with urea (Sundstol and Coxworth, 1984). The potential degradability (a + b) was higher in the preserved than the dry straw (63 vs. 49%). Unlike our previous observation (Chowdhury and Huque, 1995), the degradation rate constant (c) was higher in the dry than the preserved straw (3.35 vs. 2.70%). Higher degradation of urea preserved straw is probably due to greater accessibility of cellulolytic enzyme to fibrous material resulting from the solubilization of hemicellulose and lignin by the ammonia generated from the hydrolysis of urea (Chesson and Ørskov, 1990). Another possibility is that urea preservation increases the NH_3 availability in the rumen, which is a major constraint to microbial fermentation.

Health

Animals fed either preserved straw or dry straw were apparently healthy and did not show any symptoms of hepexcitibility, nervousness, impaired vision or movement. Perdok and Leng (1987) showed roughages with high

TABLE 4. INTAKE OF ANIMALS FED EITHER DRY STRAW OR PRESERVED STRAW SUPPLEMENTED WITH FISH MEAL AND WHEAT BRAN

	Dry straw	Preserved straw	SED ($df = 6$)	Significance
Dry matter (DM) intake (kg/d):				
Total	5.06	6.30	1.085	NS
Straw	3.62	4.86	1.89	NS
Wheat bran	1.35	1.35	–	–
Fish meal	0.090	0.090	–	–
DM intake (g/kg $W^{0.75}$/d)	71	89	6.2	$p < 0.05$
DM intake (% of live weight)	1.80	2.13	0.141	NS
Straw DM in (% of live weight)	1.27	1.64	0.153	NS
Digestible organic matter (OM) intake (kg/d)	2.39	3.24	0.333	$p < 0.05$
Metabolizable Energy Intake from Straw (MEI MJ/d)#	35.65	58.76	–	–
N intake from straw alone (g/d)[1]	39.39	80.87	–	–
Rumen degradable N (RDN) from straw (g/d)[2]	21.66	56.61	–	–
Digestible RDN (RDN × 0.8 × 0.75) from straw (g/d)[3]	13.00	33.97	–	–
Rumen undegradable N (UDN) from straw (g/d)[4]	17.73	24.26	–	–
Digestible UDN (or DUN) from straw (g/d)[5]	5.32	11.89	–	–
Net available N (Dig. RDN + DUN) from straw at the intestinal level (g/d)	18.32	45.86	–	–

Estimated from the degradability of straw as ME (MJ/kg DM) = 2.756 + 48h DM loss × 0.173. (Dr. E. R. Ørskov, RRI, Personal Communication).

[1] Estimated from the N content in the straw.

[2] Assuming N degradability in the rumen of dry and preserved (ammoniated) straw of 55 and 70% respectively (Walli et al., 1993).

[3] Assuming 0.80 of the total microbial N is amino acid N, having intestinal digestibility of 0.75 (ARC, 1980).

[4] Estimated as UDN = Total N − RDN.

[5] Assuming digestibility of UDN of dry and preserved straw of 30 and 35% respectively (Sampath et al., 1993).

reserve carbohydrates prior to ammoniation liable to cause hyperexitibility when fed after ammoniation. Urination and defecation habit were also similar in both groups except that preserved straw fed animals voided faeces that were more darker and higher moisture content than the dry straw fed animals. Latter is probably due to the higher out -flow rate of rumen digesta associated with the higher degradability and intake of preserved straw.

Intake

Dietary intake are presented in table 4. Both total and straw DM intake were non-significantly ($p > 0.05$) higher in the preserved straw than the dry straw fed animals and they consumed straw dry matter at the rate of 1.64 and 1.27% of their live weight respectively.

The estimated metabolizable energy (ME) intake from dry and preserved straw were 35.65 and 58.76 MJ/d respectively; while the respective calculated maintenance ME (MEm) requirement were 39.42 and 40.24 MJ/d (assuming MEm = 450 KJ/kg $W^{0.75}$ daily, and the efficiency of utilization of MEm is 0.80, ARC, 1980).

Assuming the N degradability of dry and preserved (ammonia treated) straw of 55 and 70% respectively (see Walli et al., 1993), the rumen degradable N (RDN) supply from two types of straw would be 13 and 34 g/d respectively. Considering the RDN requirement of 1.248 g /MJ ME (ARC, 1980), even feeding preserved straw alone can not meet the RDN requirement for optimal rumen function. However, supplementation of RDN to ammoniatreated straw diet (with 5% molasses) in the form of urea or soyabean meal, did not improve the efficiency of microbial protein production in cattle (Moller and Hvelplund, 1982). In this trial, the estimated net available amino acid N at the tissue level were 18.32 and 45.86 g/d for the dry and preserved straw fed animals respectively (see table 4); while their respective calculated tissue maintenance requirement for N (TMN) were 30.66 and 31.30 g daily (assuming TMN of 0.35 g/kg $W^{0.75}$/d and the efficiency of utilization of N for maintenance is 0.80).

From above discussion it is apparent that the preserved straw alone can support the MEm and TMN requirements while the dry straw can not.

Digestibility

Digestibilities of different nutrients are shown in the table 5. Total gut digestibilities of DM, OM and ADF were significantly ($p < 0.05$) higher in the preserved straw group. This is probably due to the well known effect of urea (ammonia) treatment reported elsewhere (See Sundstol and Coxwarth, 1984). Protein digestibility, however, was significantly ($p < 0.01$) higher in the dry straw than the preserved straw fed animals. This higher crude protein digestibility in the dry straw fed animals, may not necessarily indicate that they had higher available N supply at the tissue level. Infact, higher crude protein digestibility in dry straw fed animals is due to the lower faecal N content. The faecal N comprises of undigested dietary N and metabolic faecal N (MFN). Microscopic observations and microbial marker study revealed that MFN was virtually all undigested microbial N (Ørskov, 1982). This undigested microbial N is proportional to the microbial N yield in the rumen. Therefore, it may be that the microbial N yield in the rumen of dry straw animals was lower than the preserved straw fed animals.

TABLE 5. TOTAL GUT DIGESTIBILITY OF DIFFERENT NUTRIENTS (%)

Nutrients	Dry straw	Preserved straw	SED	Significance
Dry matter	41	52	2.4	$p < 0.01$
Organic matter	52	59	2.0	$p < 0.05$
Crude Protein	48	30	4.1	$p < 0.01$
Acid detergent Fibre	54	74	3.8	$p < 0.01$

Growth rate

Growth response of animals are shown in the table 6. Live weight gain was nonsignificantly ($p > 0.05$) higher in the preserved than the dry straw (707 vs 580 g daily) fed animals. However, the conversion of 1 MJ of ME to live weight was better in the dry straw (16 g) than the

TABLE 6. GROWTH RESPONSE OF ANIMALS FED DIFFERENT DIETS

	Dry straw	Preserved straw	SED	Significance
Initial Live weight (kg)#	233	228	20.67	NS
Final Live weight (kg)#	289	297	23.44	NS
Total Experimental Periods (Days)	97	97	–	–
Growth Rate (g/d)#	580	707	79.2	NS
Feed Conversion Efficiency				
Daily Live Wt. gain (g/MJ MEI)	16	12	–	–
kg DMI/kg gain	8.72	8.91	–	–

Calculated from the regression : Live weight vs. Time.

preserved straw (12 g) fed animals. Apparently lower efficiency in the preserved straw group was due to higher ME intake. These efficiency values, however, were much higher than that observed in growing Bangladeshi bulls fed untreated rice straw diet supplemented with 2 kg wheat bran and 0.5 kg oil cake (7 g gain/MJ MEI, Chowdhury et al., 1994). Similarly, Webster (1989) achieved 4.6 g gain per MJ MEI in Frisian × Hereford cross steers on a poor quality hay diet. Silva et al. (1989) also showed a liveweight gain of 4.6 g/MJ MEI on a ammoniated straw diet. On the other hand, Saadullah (1984) reported a live weight gain of 14 g/MJ MEI on an untreated straw diet supplemented with fish meal. This high feed conversion efficiency on straw diet has been attributed to more efficient utilization of nutrients due to more appropriate balance (acetogenic : glucogenic ratio) aided by fish meal supplementation. Further, extra amino acid from fish meal that escape ruminal degradation and digested and absorbed postruminally, utilized more efficiently as amino acid source for tissue protein accretion (Walli et al., 1993). Besides, higher plasma amino acid concentration due to fish meal supplementation, enhances anabolic activity by increasing the circulating plasma insulin, growth hormone and Insulin like Growth Factor-I (IGF-1) concentration (Chowdhury, 1992).

Conclusion

It can be concluded that fresh and wet rice straw with relatively lower moisture (say 400 to 500 g H_2O/kg straw) can be preserved (without drying) with 5% urea (without polythene or any other cover). This will not only avoid the labour cost and time associated with drying process but also improve the nutritive value of the straw in terms of CP content, intake, rumen & total gut digestibility and growth rate. Urea treatment method traditionally involve in ensiling straw with urea under airtight condition for 10 to 15 days. While this can be done in much simpler was as discussed earlier. Although some of the ammonia is being lost in this method, but it will avoid the costly air-tighting procedure, with no apparent effect on the nutritive value.

Uncertainties

Straw that has been preserved here was relatively dry (600 g DM per kg fresh straw) and was preserved during the dry period (January to May). While, fresh straw (from Boro and Aus) during the monsoon season invariably have DM ranges between 300 to 400 g/kg. We don't know yet whether straw with higher moisture content (say between 600 to 700 g H_2O/kg straw) and preserved during wet season (June to August), response in the same way as per as the preservation quality and the nutritive value are concerned.

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