STRAW PRESERVATION UNDER WET CONDITION DURING MONSOON IN BANGLADESH: EFFECT OF PRESERVING WET STRAW WITH UREA ON ITS KEEPING QUALITY AND NUTRITIVE VALUE IN CATTLE WHEN FED ALONE OR SUPPLEMENTED WITH CONCENTRATE

S. A. Chowdhury[1], K. S. Huque and M. E. Haque

Bangladesh Livestock Research Institute, Savar, Dhaka 1341, Bangladesh

Summary

During the monsoon in Bangladesh, the possibility of preserving wet (700 g H_2O) straw by urea (50 g/kg straw DM) with or without polythene cover has been studied. The quality of preserved straw (PS) in terms of colour, smell and fungal infestation were recorded. Nutritive value of the PS was compared to that of a dry straw (DS) in two separate feeding trials on growing bulls (about 290 kg) without (Expt. 1) or with (Expt. 2) concentrate supplements. Over 96% of the wet straw was excellently preserved for over 5 months when covered with polythene in horizontal heaps (of appx. 4 tons). Whereas only 33% of the straw was well preserved in the uncovered (dome shaped) heaps (of approximately 9.5 tons). Each ton of wet straw costed Tk. 1413 and its preservation cost incurred Tk. 354. Urea preservation increased the crude protein content (95 vs. 50 g/kg), dry matter (DM) degradability at all (8, 16, 24, 48, 72 and 96) hours of incubation and at 48 hours, DM degradability (%) were 45 and 25 respectively for the PS and the DS. When fed alone, DM intake (75 vs. 106 g/kg $W^{0.75}$/d), total microbial N yield (27 vs. 54 g/d) and growth rate (−379 vs. 283 g/d) were higher ($p < 0.01$) in the PS than the DS. Supplementation of concentrate reduced the straw DM intake both in the DS (51 g/kg $W^{0.75}$/d) and the PS (958 g/kg $W^{0.75}$/d), but the substitution rate (SR%) was higher in the PS (42) than the DS (27). Higher substitution rate was probably responsible for the reduction in the differences between the DS and PS in their nutrient digestibilities, total microbial N yield (62 vs. 64 g/d) and growth rate (669 vs 339 g/d) when supplemented with concentrate. On 28th day of Expt. 2, feeding PS from one of the polythene covered heaps resulted nervous disorder due to unknown reason(s). Further studies on the effect of size and shape of heap on the preservation quality need to be determined.

(**Key Words**: Wet Straw, Preservation, Urea, Supplementation, Nutritive Value)

Introduction

During the monsoon (from June to August) in Bangladesh, heavy rain fall (337 mm) and high humidity (86%) do not allow sun drying of rice straw of Boro and Aus crops which contain about 60 to 70% moisture. Invariably most of the straw is being rottened accounting nearly 43% of the total straw produced annually. Workers (see Chowdhury and Huque, 1995a) of the Bangladesh Livestock Research Institute showed that wet straw can be preserved by adding urea (5% of straw DM) as a preservative, for over six months. provided the liberated ammonia is trapped properly. The same workers from their subsequent works (Chowdhury and Huque, 1995b) with the fresh and wet straw of relatively lower moisture content (400 g/kg straw), showed that the straw can be preserved by urea without a polythene or any other cover to create an air-tight condition. However, it is yet to be determined whether the same method could be applied for the preservation of straw with relatively higher moisture content (> 600 g/kg straw).

Chowdhury and Huque, (1995b) showed that the, supplementation of concentrate (wheat bran and fish meal) increased the straw dry matter (DM) intake and growth rate of cattle fed urea preserved straw compared to that of a dry straw. However, it is not known whether preserved straw alone can maintain this higher intake or growth rate without concentrate supplementation.

[1]Address reprint requests to Dr. S. A. Chowdhury, Bangladesh Livestock Research Institute, Savar, Dhaka 1341, Bangladesh.

Received August 30, 1995
Accepted January 9, 1996

The present experiment has, therefore, been designed to:

(1) determine the keeping quality of preserved straw with relatively higher moisture content covered with or without polythene;

(2) determine the nutritive value of preserved straw either fed alone or supplemented with concentrate.

Materials and Methods

Source and type of straw

During July, 1994, fresh and wet (700 g H_2O/kg) straw was collected from two different locations e.g., Manikgang and Mymensingh districts of Bangladesh. They were of unknown varieties of Aus straw and nothing was known about their agronomical practices or grain yields.

Preservation method

Straw was preserved in 6 heaps by ensiling with urea at the rate of 50 g/kg straw dry matter. Three heaps, containing approximately 4 tons of fresh and wet straw, were built on the ground horizontally and covered with polythene. Rest of the heaps, each containing approximately 9.5 tons of straw, were also built on the ground but were of dome shape in structure and were not covered with polythene. The straw was preserved for five months from July, 1994 to December, 1994.

Preservation quality

After the end of preservation period, straw was checked for temperature, colour, smell and presence of any fungal infestation. Samples were taken for chemical analyses and *in sacco* dry matter degradability. For observing the preservation condition of straw, one heap was sectioned longitudinally, while the rest were sectioned horizontally.

Rumen degradability

Three bulls fitted with rumen cannula of 40 mm diameter were used for determining rumen degradability of the preserved wet straw (PS) and sundried straw (DS) according to the method described by Ørskov et al. (1980). Nylon bags containing 1 g of air dry sample were incubated into the rumen at 8, 16, 24, 48, 72 and 96 hours. Dry matter losses of each type of straw at different incubation periods and data for each type of straw were determined and described by the exponential equation of McDonanld (1981), $p = a + b(1 - e^{-ct})$, where p is degradation in time t and a, b and c are constant. Constant 'a' represents the readily soluble fraction, '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.

Feeding trial

In order to determine the nutritive value, the PS which was acceptable to the animals were fed with or without supplementation of a concentrate mixture.

Experiment 1. Effect of feeding urea preserved straw as a sole feed for cattle

Animals and the experimental diets

Having divided into two equal groups, ten local growing bulls of about 3 years of age and 290 kg live weight, were randomly allocated to DS or PS diets. The DS was of unknown varieties and the PS was taken from the polythene covered heaps. The animals were fed the straws *ad libitum* and had free access to drinking water only. Since the experimental animals were not given any supplement except that of straw, the feeding trial was conducted in 24 days.

Experiment 2. Effect of feeding urea preserved wet straw supplemented with concentrate on the growth performances of bulls

Animals and the experimental diets

At the end of Experiment 1, each bull of the DS and PS groups were given daily 3 kg concentrate for additional period of 43 days. The concentrate mixture was composed of wheat bran (70%), mustard oil cake (15%), pulse (*Latharus sativum*) bran (13.5%), salt (1%) and oyestershell (0.5%). The chemical composition of the mixture is presented in table 1.

TABLE 1. CHEMICAL COMPOSITION OF THE FEED INGREDIENTS USED IN THE FEEDING TRIAL

Ingredients	DM (g/kg fresh ingredients)	g/Dry matter (DM)		
		Organic matter (OM)	Crude protein (CP)	Acid detergent fibre(ADF)
Preserved straw	871	834	95	430
Dry straw	904	886	50	451
Con. Mixture	892	934	125	123

Digestibility, N balance and ME estimation

In both the experiments, the bulls were transfer to metabolic stalls for a period of 10 days. After initial 3 days adjustment, digestibilities and N balance were measured for 7 days. During this period, in addition to the usual record of feed offered and residue left, 24 hours faeces and urine production were also recorded. Digestibility of the individual nutrient was measured from its intake and faecal excretion. N balance was calculated as the difference between the N intake and faecal and urinary N excretion. The ME content of straw was estimated from the equation ME = 2.756 + 48 h DM degradability % × 0.1073 (E.R. Ørakov, personal communication).

Live weight change

In both trials, animals were weighed weekly before the morning feed. Live weight change was calculated as the slope of the individual regression of live weight vs time.

Chemical analyses

Samples of feeds, refusals, faeces analysed for dry matter, organic matter, crude protein (CP, N × 6.25) and acid detergent fibre (ADF) according to AOAC (1984). Urinary N was also measured in the same way. Microbial N production of an animal was estimated from its urinary allantoin excretions, measured after the method described by Chen and Gomes (1992).

Statistical analyses

Simple 't' test was used for measuring the differences of means of each variate with appropriate standard error of mean differences (SED). Simple linear regression of the form y = a + bx was used for determining the slope between two variables where appropriate. Data were analysed as per the methods described by Snedecor and Cochran (1967).

Results

Preservation qualities of the uncovered straw

According to the preservation condition of straw, polythene uncovered heaps can be divided into five sections, e.g., top, periphery (about 10 cm), outer middle (about 25 cm), inner-middle (about 45 cm) and the central (figure 1a). Preservation qualities and the fractions of straw of these sections are presented in table 2. In all

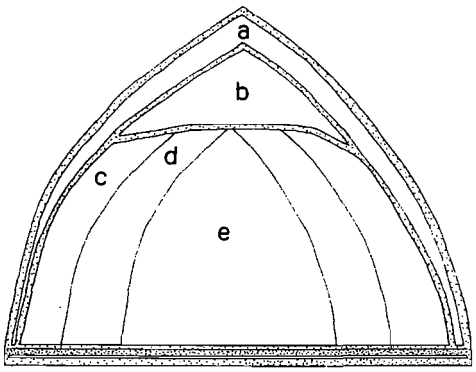

Figure 1a. (a) Peripherial dry straw (about 10 cm), no ammonia or fungus: (b) Top layer rotten and dry: (c) Outer middle layer (25 cm), slightly moist and fungated, no ammonia: (d) Inner middle layer (45 cm), slightly moist, ammoniated but no fungus: (e) central layer, moist, burned and slightly ammoniated.

TABLE 2. PRESERVATION CHARACTERISTICS OF STRAW OF DIFFERENT SECTIONS OF THE HEAP NOT COVERED WITH POLYTHENE

Section	Moisture (g/kg)	Fraction (%) of total straw	Colour	Smell	Temp. (°C)	Fungl infesta-tion	Preservation Condition
Top	168	3.56	light grey	No smell of NH_3	17	Yes	Not well preserved
Periphery	168	8.64	light greyish brown	No smell of NH_3	17	No	Not well preserved
Outer Middle	242	33.38	Dark brown	Slightly ammoniated	29	Slight	Well preserved
Inner middle	242	40.33	Blackish brown	ammoniated	40	No	Not well preserved, slightly burned
Central	452	14.09	Black	Slightly ammoniated	60	No	Burned

three heaps, except in the outer middle layer which constitute about one third of the total straw, straw in the rest sections were not preserved properly. With the rise in moisture and temperature content, straw quality deteriorated from the periphery towards the centner where, straw turned into black due to heat.

Preservation qualities of polythene covered straw

Transverse sections of the all three polythene covered heaps revealed that they can be divided into surface (about 5 cm deep) and the inner sections (See figure 1b). Preservation qualities and the straw proportions of different sections are presented in table 3. Most of the straw (96%) was preserved excellently with a relatively lower (32℃) inside temperature. Straw in the surface section was rottened having pungent smell.

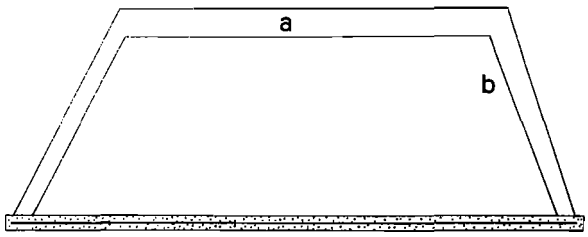

Figure 1b. (a) Wet, fungated with rotten pungent smell: (b) Inner layer, moist, ammoniated and well preserved.

TABLE 3. PRESERVATION CHARACTERISTICS OF STRAW OF DIFFERENT SECTIONS OF THE HEAP COVERED WITH POLYTHENE

Section	Moisture (g/kg straw)	Fraction of the heap (%)	Colour	Smell	Temp. (℃)	Fungal infestation	Preservation condition
Surface	678	3.77	Light brown	Pungent	17	No	Not preserved
Inner	330	96.00	Dark brown	Strongly ammoniated	32	No	Excellently preserved

Preservation cost

The cost of preserving wet straw incurred from urea, labour and polythene (where used) in presented in table 4. The obvious result of polythene use was the increase of preservation costs in the covered (Tk. 340/ton of wet straw) than the open (Tk. 130/ton of wet straw) heaps. However, when the proportion of the preserved straw in the covered (96%) and open (33%) heaps was considered (see table 2 and 3), the cost difference per ton of straw preservation in the two types of heaps was minimum (Tk. 354 and 391 respectively). The losses of straw due to rottening were equivalent to Tk. 219 and 8530 in the covered and open heaps respectively.

TABLE 4. COST OF WET STRAW PRESERVATION BY UREA WITH OR WITHOUT POLYTHENE COVER

Heap No	Group	Total amounts of wet straw	Valoue of the wet straw (Tk.)	Urea		Labour		Polythene		Total Cost	% of straw well preserved	Total amount of well preserved straw	Cost / ton of straw preservation
				Amount (kg)	Cost (Tk)	Number	Cost (Tk)	Amount (Yards)	Cost (Tk)				
1	Open	8.960	12,644	130	650	12	480	–	–	1,130	33.38	2.670	423
2	Open	9.420	13,315	141	707	13	520	–	–	1,227	33.38	3.145	390
3	Open	8.000	12,214	120	600	12	480	–	–	1,080	33.38	2.991	361
4	Sealed	3.875	5,477	50	540	6	240	20	540	1,320	96.00	3.720	354
5	Sealed	3.875	5,477	50	540	6	240	20	540	1,320	96.00	3.720	354
6	Sealed	3.875	5,477	50	540	6	240	20	540	1,320	96.00	3.720	354

Degradation characteristics

Since the wet straw in the open heap was not well preserved, degradation characteristics were measured only for the straw of polythene covered heaps compared to that of a dry straw. Urea preservation significantly ($p < 0.05$) increased the DM degradability (%) of the wet straw at all (8, 16, 24, 48, 72 and 96) hours of incubation (see table

5). The 48 hours DM degradability of PS and DS were 45 and 25% respectively. The rate (1.82 vs. 1.39) and the extent (a + b, 81 vs 62) of degradation were also nonsignificantly ($p > 0.05$) higher in the PS than the DS.

TABLE 5. NYLON BAG DEGRADABILITY (%) OF POLYTHENE COVERED PRESERVED STRAW AT DIFFERENT HOURS OF INCUBATION IN THE RUMEN WITH FACTORS OF EXPONENTIAL EQUATION $P = A + B\ (1 - e^{-ct})$ DESCRIBING THE DEGRADATION (P) WITH TIME (T)

Parameters	Dry straw	Preserved straw	SED	Significance
Hours of incubation				
8	4	14	2.07	$p < 0.01$
16	8	23	2.76	$p < 0.01$
24	16	31	4.20	$p < 0.05$
48	27	45	3.09	$p < 0.01$
72	39	58	6.57	$p < 0.05$
96	43	63	4.23	$p < 0.01$
Factors of Exp. equation				
a	−4	4	5.23	NS
b	66	77	7.65	NS
c	1.39	1.82	0.541	NS

Health of the experimental animals (expt. 1)

Animals fed either DS or PS were apparently healthy and did not show any abnormal nervous symptoms. Feeding, urination and defecation habits were similar in both the groups of animals except that faeces in the PS fed animals was darker and had a higher moisture content (284 vs. 252 g/kg).

Intake (expt. 1)

Dry matter (DM) and the estimated metabolizable energy (ME) are shown in table 6. The straw DM intake either on the basis of daily total (7.47 vs. 4.76 kg/d), or per cent liveweight (2.56 vs. 1.72 kg/d) or metabolic body weight (106 vs. 75) were significantly ($p < 0.01$) higher in the PS than the DS. The estimated ME intake from PS and DS were 79 and 35 MJ/d respectively. The rumen degradable N (84 vs. 21 g/d) was significantly ($p < 0.01$) higher in the PS (84 g/d) than the DS (21 g/d).

Microbial N yield (expt. 1)

Total microbial N yield was higher ($p < 0.01$) in the PS (54 g/d) than the DS (27 g/d) fed animals (see table 6). The efficiency of microbial N production (expressed as g microbial N/kg digestible organic matter apparently fermented in the rumen (DOM × 0.65, ARC, 1984) was also higher ($p > 0.05$) in the former (21 g/kg DOMR) that the latter (16 g/kg DOMR) groups of animals. The estimated available amino acid N at the tissue level was also higher in the PS (413 mg/kg $W^{0.75}$/d) that the DS

TABLE 6. DRY MATTER, ESTIMATED ME AND N INTAKE IN ANIMALS FED EITHER DRY OR PRESERVED STRAW ALONE

	Dry straw	Preserved straw	SED	Significance
Total straw DM intake kg/d	4.76	7.47	0.483	$p < 0.01$
Straw DMI (% of LWt) kg/d	1.72	2.56	0.263	$p < 0.01$
Straw DMI (g/kg $W^{0.75}$/d)	75	106	8.5	$p < 0.01$
Digestible OMI (Kg/d)	2.83	4.03	0.179	$p < 0.01$
ME intake (MJ/d)	35	79	–	–
N intake (g/d)	38	112	9.36	$p < 0.01$
Rumen degradable N intake from straw[1]	21	84	3.95	$p < 0.01$
Total Microbial N Yield (g/d)[2]	27	54	8.1	$p < 0.01$
Microbial N yield/kg DOMR[3]	16	21	3.7	NS
Available amino acid N (mg/kg $W^{0.75}$/d) at the tissue level[4]	214	413	–	–

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

[2] Estimated from the urinary purine derivatives excretion after Chen and Gomes (1992).

[3] Digestible organic matter apparently fermented in the rumen (DOM × 0.65; ARC, 1980).

[4] Assuming 0.80 of the total microbial N is amino acid N, having intestinal digestibility of 0.85 and the utilization of microbial amino acids (0.80) (Storm et al., 1983).

(214 mg/kg $W^{0.75}$/d).

Digestibilities (expt. 1)

digestibilities of different nutrients are shown in table 7. The dry matter (59 vs. 55%), organic matter (65 vs. 61%) and N digestibilities (46 vs. 44%) were higher ($p > 0.05$) but the ADF digestibilities (64 vs. 71%) were lower ($p > 0.05$) in the PS than the DS fed animals.

TABLE 7. NUTRIENT DIGESTIBILITIES (%) OF ANIMALS FED DRY OR PRESERVED STRAW ALONE

Parameters	Dry straw	Preserved straw	SED	Significance
Dry matter	55	59	5.03	NS
Organic matter	61	65	4.97	NS
Nitrogen	44	45	12.2	NS
Acid detergent fibre	71	64	6.71	NS

Growth and N balance (expt. 1)

The data of N balances and live weight changes are presented in table 8. Both the groups of animals had a positive N balance and the PS fed animals had higher ($p < 0.01$) N balance (653 mg/kg $W^{0.75}$/d) than the DS (138 mg/kg $W^{0.75}$/d) fed animals. The preserved straw fed animals gained at the rate of 283 g while, the DS fed animals lost 379 g live weight daily.

TABLE 8. PERFORMANCE OF ANIMALS FED EITHER DRY OR PRESERVED STRAW ALONE

Parameters	Dry straw	Preserved straw	SED	Significance
N balance (mg/kg $W^{0.75}$/d)	138	653	86	$p < 0.01$
Live weight change (g/d)	−379	283	223.3	$p < 0.01$

Health of animals (expt. 2)

From 28th day of the second feeding trial, one of the bulls of PS group, showed a syndrome similar to that of hyperexcitability. The symptoms were apparent impairment of vision, trembling, uncoordinated hindgut movement, loss of balance, loss of appetite. However, there were no salivation or frothing from the mouth and the urintation and the defecation were normal as observed before. Similar symptoms were also shown by the other two animals of the same group on 34th day of the trial. This symptom was not apparent until the start of feeding of straw from the third heaps of the polythene covered PS.

Intake of diets (expt. 2)

Dietary intakes of DM and ME are shown in table 9. The straw DM intake was nonsignificantly ($p > 0.05$) higher in the PS (4.3 kg) than the DS (3.76 kg) fed bulls,

TABLE 9. INTAKE AND MICROBIAL N YIELD OF ANIMALS FED EITHER DRY OR PRESERVED STRAW SUPPLEMENTED WITH CONCENTRATE

	Dry straw	Preserved straw	SED	Significance
Total DM intake (kg/d)	6.44	6.98	0.315	NS
Straw DM intake (kg/d)	3.76	4.30	0.315	NS
Conc. DM intake (kg/d)	2.68	2.68	–	–
Conc. DM intake as % of LWt.	0.86	0.86	–	–
Straw DM intake as % of LWt. (kg/d)	1.25	1.49	0.162	NS
Straw DM intake g/kg $W^{0.75}$/d	51	58	–	–
Dig. OM intake (kg/d)	3.26	4.75	0.379	$p < 0.01$
ME from straw (MJ/d)	28	45	–	–
N from straw (g/d)	188	409	26.1	$p < 0.01$
Microbial N yield (g/d)[1]	62	64	8.7	NS
Available amino acid N at the tissue level[2]	456	470	–	–
Microbial N g/kg DOMR[3]	29	21	–	–

[1] Estimated from the urinary allantoin excretion.

[2] Assuming 0.80 of the total microbial N is amino acid N, having intestinal digestibility of 0.85 and the utilization of microbial amino acids (0.80) (Storm et al., 1983).

[3] DOMR, digestible organic matter apparently fermented in the rumen (DOM × 0.65, ARC 1980).

resulting in the higher ME and N intake in the former group.

Microbial N yield (expt. 2)

Total microbial N yield were almost similar ($p > 0.05$) in the DS (62 g/d) and the PS (64 g/d) fed bulls when supplemented with concentrate (see table 9). The efficiency of microbial N yield (g N/kg DOMR) were infact higher ($p > 0.05$, *not significant*) in the DS (29 g/kg DOMR) than the PS (21 g/kg DOMR).

Digestibility (expt. 2)

Digestibilities of different nutrients in bulls fed either DS or PS supplemented with concentrate are given in table 10. Total gut digestibility of DM (68 vs. 51; $p < 0.01$), OM (70 vs. 60; $p > 0.05$, *non significant*), CP (52 vs. 44; $p > 0.05$, *non significant*) and ADF (55 vs. 39; $p > 0.05$, *non significant*) were higher in the diet of PS than the DS.

TABLE 10. DIGESTIBILITIES OF DIFFERENT NUTRIENTS IN ANIMALS FED DRY OR PRESERVED STRAW SUPPLEMENTED WITH CONCENTRATE

	Dry straw	Preserved straw	SED	Significance
Dry matter	51	68	5.4	$p < 0.01$
Organic matter	60	70	6.4	NS
Crude protein	44	52	11.0	NS
Acid detergent fibre	39	55	9.7	NS

Performance of animals (expt. 2)

Live weight gains of the bulls are given in table 11. During the 43 days feeding trail, DS fed animals had a higher ($p > 0.05$) live weight gain (669 g/d) than that of the PS (393 for all 5 animals or 563 g/d excluding the sick animals) fed animals. The former had also better feed conversion efficiency (9.63 kg/kg gain) than the latter (12.39 kg/kg gain).

TABLE 11. PERFORMANCE OF ANIMALS FED EITHER DRY OR PRESERVED STRAW SUPPLEMENTED WITH CONCENTRATE

	Dry straw	Preserved straw	SED	Significance
Initial live weight (kg)*	281	294	33.1	NS
Final live weight (kg)*	310	311	33.2	NS
Live weight (for all animals) gain (g/d)*	669	393	174	NS
Live weight (excluding the sick animals) gain (g/d)*	669	563	182	NS
kg DM intake/kg gain*	9.63	12.39	–	–

* Calculated as the regression between live weight vs. time.

Discussion

Preservation quality

Unlike the straw containing lower (400 g/kg) moisture (see Chowdhury and Huque, 1995b), the straw with a relatively higher moisture (700 g/kg) content can not be preserved with out polythene covers. The factors, namely ammonia levels and size & shape of straw heaps, may be responsible for the observed differences. Ammonia causes rise of straw pH (> 8) that inhibit the oxidative or microbial fermentation (Wilkins, 1988). High initial ammonia level may have prevented any microbial fermentation of straw in the large uncovered heaps. Although we did not measured the NH_3 level in the PS, but it is obvious that in the open heaps, much of the ammonia escaped with the increase of preservation period. Similarly, moisture content of the straw in peripheries evaporated at a higher rate than that of the center (see table 2). This higher moisture content in the center with the increased preservation period caused straw burning (1 kg straw DM can generated 1.318 MJ heat, assuming 1 kg straw contain 84 g sugar (Perdok and Leng, 1987) and 1 g of sugar oxidized to yield 15.68 kJ heat) due to the oxidative fermentation of readily available carbohydrates. Therefore, the preservation quality of straw improved gradually from the center towards the periphery. This may indicate that the fresh and wet straw with higher moisture content (> 600 g/kg) may be preserved with urea in smaller heaps (say 3-5 tons) without been covered with polythene. Chowdhury and Huque (1993) reported an excellent preservation of about 3 tons of fresh and wet (about 700 g H_2O/kg) straw in uncovered dome shaped heaps for 75 days.

In the polythene covered heaps, ammonia was trapped properly and gave a good preservation condition for straw. However, temperature inside the heap was much higher (32℃) than the outside (17℃). The temperature difference may have indicated that carbohydrate was fermented to

some extent even at the presence of high level of ammonia (see table 3). Therefore, the actual threshold level of ammonia required for optimum preservation may depends on the temperature of the heap which probably depends on the level of moisture in straw and size & shape of heap.

Preservation cost/benefit

The cost effectiveness of the preservation method may be understood from the fact that each ton of wet straw costs about Tk. 1413 and its preservation with urea and polythene cover will cost Tk. 354. Avoidance of polythene use is highly desirable for reducing farmers hard currency expenditures and environmental pollution.

The benefit of preserving wet straw with urea is three folds. Firstly, it increased the availability of straw which would otherwise be wasted. Secondly, due to increase in CP (50 vs. 90 g/kg DM), DM intake (75 vs. 106 g DM/kg $W^{0.75}$/d), ME availability (10.46 vs. 7.44 MJ/kg DM), rumen microbial N yield (21 vs. 16 g/kg DOMR) and substitution rate (i.e., reduction in the proportion of straw intake due to supplementation 41.8 vs. 27.3%), the nutritive value of preserved straw would be approximately (10.46/7.44) 1.4 times higher than that of the dry straw. Thirdly, since the daily energy intake increased, a smaller proportion of intake is necessary for maintenance and a larger percentage is available for growth and milk production. As a result, growing animals will reach first calving or market weight at a younger age; milking animal will yield more milk per day.

Degradability

As expected, rumen degradability and the rate and the extent of degradation were higher in the PS than the DS which is similar to our previous observations (Chowdhury and Huque, 1995a, 1995b). This was probably due to the increase in the rumen cellulolytic activity resulted in the solubulization of ligno-cellulose bonds of straw and also due to the increase in the rumen NH_3 level (Chesson and Ørskov, 1990).

Health

On the 52nd day (24 days in the 1st trial + 28 days in 2nd trial) of PS feeding, animals started showing syndromes close to that of hyperexicitibility. Perdok and Leng (1987) reported that roughages with a higher content of reserve carbohydrates prior to ammoniation appeared to particularly labile to cause hyperexitibility when fed after ammoniation. To cause hyperexcitability by the ammoniated feeds, they (Perdok and Leng, 1987) gave following prerequisites : i) the material being ammoniated must reach a temperature of at least 70℃; ii) depending on the level of toxic compound in the straw, the ammoniated straw must comprises at least 50% of diets; iii) the feed must contain a fair level of reducing sugars prior to ammoniation. Their observed symptoms include restlessness, rapid blinking, apparent impairment of vision, involuntary ear twitching, trembling, loss of balance, frequent urination and defecation, rapid respiration, salivation, frothing at the mouth, bellowing and sweating. However, only few of these symptoms were apparent in the affected animals of the present trail. Also, other symptoms like sudden stampeding involving galloping in circles and colliding with other animals or fences which lasted for up to 5 minutes and periodically appeared in 20-30-min intervals and eating voraciously in between attacks; were not observed in the affected animals.

Hyperexitibility reported (Pardok and Leng, 1987) to be caused by 4 methyl-imidazole (4ME-I), a compound produced from the reaction of glucose and ammonia in the presence of moisture and high temperature (> 70℃). In the present trial, the highest temperature recorded in the preserved straw was 60℃ in open heaps, which is less than the temperature (70℃) required for the formation of 4ME-I. Neither did we measure the 4ME-I content in the preserved straw nor the reducing sugar content in the fresh and wet straw to be conclusive about an alleged relationship between 4ME-I this compound and the symptoms observed. However, similar symptoms were also reported to be caused by Mg deficiency due to chelation of Ca^{2+} and Mg^{2+} ions with 4ME-I or other compound(s) in the blood.

None of the PS fed animals in our previous trials (see Chowdhury and Huque, 1993 and 1995b) showed such symptoms. Even in the present trial, animals were apparently healthy till they started consuming straw from the third heap. It may be that toxin formed in the third heap was responsible for the observed syndrome, as, symptoms of hyperexicitibility reported to be developed within three days of feeding thermoammoniated straw (Perdok and Leng, 1987). Development of toxic compound may depend on straw types as the reducing sugar content in straw depends on the extent of translocation of reserve carbohydrates from the stem and leaf to the grain.

Intake

Increases in the straw DM intake due to urea preservation is similar to our earlier observation in cattle fed urea preserved straw (see Chowdhury and Huque, 1995b). This is probably due to higher rate of degradation

of preserved straw (see table 6) which, in turn increases the passage rate of digesta (Faichney, 1986) and thus increased the microbial N yield (see table 7). Higher postruminal microbial N supply increases the circulating amino acid concentration in the plasma and thus increases the utilization of acetogenic substrates (e.g., acetate, butyrate, acetoacetate) for the synthesis of tissue component (Lobely, 1990). This enable animal to reduce metabolic heat production, which, otherwise would have increased body temperature and animals would then reduce its intake (Leng,1990).

However, Ørskov et al. (1991) showed that the excess acetate on a roughage diet does not increases the heat increment in ruminant rather excreted through urine. Therefore, the issue of metabolic control of roughage intake in still a subject of debate.

When fed alone, DM intake in both DS and PS straw were much higher in the present trail than that reported straw intake in cattle of 46-87 g/kg $W^{0.75}$/d by Prasad et al. (1993). Higher intake by the local cattle on straw diet has been reported by Saadullah (1984), who showed that the rumen volume is much higher in the local than exotic animals. Supplementation of concentrate at the rate of 0.86% of live weight, in the present trial, reduced the straw DM intake both in the DS and the PS. However, the substitution rate (SR) was higher for PS (0.42) than the DS (0.27). Similarly, Creek et al. (1984) showed that SR was higher in the treated straw (0.55) than the untreated straw (0.42). The observed grater reduction of straw DM intake due to concentrate supplementation in the PS fed animals suggest that they were able to consume PS enough to meet their daily energy requirements when fed alone. It also means that the value of PS become less important as the level of supplementation increased. Higher supplement required on untreate straw than treated straw has been reported elsewhere (see Prasad et al., 1993).

Digestibility

Higher total gut digestibilities of DM, OM and N in the preserved straw fed (without supplement) animals, agree our previous results of straw preservation with urea in cattle (see Chowdhury and Huque, 1995b). Supplementation of concentrate (0.86% of live weight) in the 2nd Expt., increased the digestibilites of DM, OM and N in the PS but not in the DS fed animals. This is probably due to higher SR in the former than the latter. However, negative associative effect of concentrate supplementation were observed on ADF digestibilities of both DS and PS. Therefore, for maximum fibre utilization, the optimum level of concentrate supplementation would be much lower than that was used in the present trial.

Microbial N yield

When DS was fed alone, microbial N yield was 16 g/kg DOMR, which is much lower than the ARC, (1980) adopted value of 30 g/kg DOMR. Very low microbial N yield (11 g/kg DOMR) in cattle on absolute DS diet has been also been observed by Chowdhury et al. (1995a). Lower availability of fermentable OM, N and other substrates (e.g., S, P, K, etc.) in an absolute DS diet known to be responsible for the lower microbial N yield (Leng 1984). when PS was fed alone, total microbial N yield was two times higher than that of DS. Similarly, feeding PS also improved the efficiency of microbial N yield. Understandably, this is due to higher fermentable OM (2.62 vs. 1.84 kg/d) and rumen degradable N (72 vs. 20 g/d) supply in the PS than the DS diet. However, total microbial N yield/d was almost similar in the DS (62 g) and the PS (64 g) when supplemented with concentrate. When fed alone, the available amino acid N supply at the tissue level in the DS and PS were 214 and 413 mg/kg $W^{0.75}$/d respectivley, which dramatically increased due to concentrate supplementation in the former (456 mg/kg $W^{0.75}$/d) but only marginally in the latter (470 mg/kg $W^{0.75}$/d). Thus, from our observation, as per as microbial N yield is concerned, the quality of straw (or other roughages) is less important when it is supplemented with a moderate level of concentrate (0.86% of live weight in this trial) in the diet. Infact, supplementation resulted in the reduction of the microbial N yield/kg DOMR in the PS than the DS diet, although DM intake/kg $W^{0.75}$/d was higher in the former than the latter. This is in contrast to the observation in sheep that the microbial N yield increases as the DM intake: body weight ratio increased (Chen et al., 1992). Therefore microbial N yield is not only determined by amount of feed consumed or bulk of the diet probably also by the appropriate balance of nutrients in the rumen.

Live weight changes

During the 34 days feeding trial, when straw was fed alone, PS fed animals gained weight while the DS fed animals lost weight. This is probably because that the estimated available ME or the amino acid N from the PS were not only enough to meet the calculated maintenance ME or N requirements (about 40 MJ/d or 31 g/d) respectively, ARC, 1980) but should also maintain a moderate growth rate. On the other hand, DS alone can not meet the maintenance ME or tissue N requirements (about 39 MJ/d or 30 g/d respectively, ARC, 1980) and should loss live weight. This is similar to our previous

observation in PS (Chowdhury and Huque, 1995b). Animals on PS diet achieved 3.6 g live weight gain per MJ ME intake which is similar to the observation of 4.6 g gain per MJ ME intake in Frisian × Hereford cross steers on a poor quality hay diet (Webster, 1989). Very low efficiency in such poor quality forage diet has been attributed to the higher ratio of acetogenic (acetate, butyrate) to glucogenic (glucose, amino acids) nutrients ratio (Leng, 1990). although the experimental period was too short to be conclusive, yet trends in the live weight change probably indicate that feeding preserved straw alone can maintain a substantial level of production.

During concentrate supplementation, DS fed animals showed higher growth response than those fed PS. One possibility is that the former group of animals was showing a compensatory growth response. The average initial live weight of the animals on dry and preserved straw were 289.5 and 290.1 kg respectively, which after 24 days on sole straw feeding became 281 and 294 kg respectively, and then increased to 310 and 311 kg respectively when supplemented with concnetrate for another 43 days. This may indicate that animals on DS when supplemented with concentrate had accelerated the growth rate (669 g/d) in order to compensate the live weight loss (−379 g/d) during sole straw feeding. As a result, at the end of the trial, both the DS and the PS fed animals attained almost a similar live weight. Chowdhury et al. (1995b) reported that sheep sustained by intragastic nutrition, showed higher protein retention during high energy supply in order to compensate the reduced rate of retention during low energy supply. Similarly, lambs given a restricted intake of protein made more rapid gains when subsequently given a high protein diet than did lambs which had not been restricted but given smaller amounts of protein during the same period (Ørskov et al., 1976). Another possibility is that the hyperexcitibility observed in some of the PS fed animals was responsible for the lower growth rate in that group compared to that of the dry straw group. When those animals were excluded, growth response of both DS (669 g/d) and PS (563 g/d) fed animals during supplementation came closer (see table 11).

Conclusion

During the monsoon, fresh and wet straw with a relatively higher moisture content (> 600 g/kg) can be preserved by ensiling with 5% urea and covered with polythene. Urea preservation increases the CP, intake, rumen degradability and total gut digestibility of straw. It also increases the microbial N yields and growth rates of growing bulls. However, the value of preserved straw become less important with high level (0.86% of body weight) of concentrate supplementation.

Uncertainties

Wet straw can be preserved with urea without using polythene cover, but the preservation quality depends upon the preservation period, size and shape of the heap and also on the moisture content. Uncertainties also exist about the cause of nervous disorder occasionally observed due to feeding PS in cattle. However, similar symptoms known to be caused by Mg deficiency or due to production of 4ME-I in the thermoammoniated straw.

Acknowledgements

The authors are thankful to the Director, Bangladesh Livestock Research Institute for providing facilities required to conduct the research work and for his kind permission to publish the article. We are greaftul to the divisional staffs who helped in this work.

Literature Cited

AOAC. 1984. Association of Official Agricultural Chemists. Official Method of Analysis (Centennial Edition). Arlington, Verginia 22209 USA.

ARC. 1980. The Nutrient Requirements of Ruminant Livestock. C.A.B. Slough, England.

ARC. 1984. The Nutrient Requirements of Ruminant Livestock. Supplement No. 1. C.A.B., Slough, England.

Chen, X. B. and M. J. Gomes. 1992. Estimation of microbial protein supply to sheep and cattle based on urinary excretion of purine derivatives - an overview of the technical details. International Feed Resources Unit. The Rowett Research Institute, Bucksburn, Aberdeen AB2 9SB, UK. Occasional Publication. pp. 2-17.

Chen, X. B., Y. K. Chen, M. F. Franklin, E. R. Ørskov and W. J. Shand. 1992. The effect of feed intake and body weight on purine derivative excretion and microbial protein supply in sheep. Journal of Animals Science. 70:1534-1542.

Chesson, A. and E. R. Ørskov. 1990. Microbial degradation in the digestive tract. In: Straw and other Fibrous By-products as feed (Editors F. Sundstol and E. Owen). Elsevier Scientific Publishers B. V., Amstardam, The Netherlands, pp. 305-339.

Chowdhury, S. A. and K. S. Huque. 1993. Study on the

development of technique for preserving straw under wet condition. Proceedings of the Workshop on 'Achievement of Research Under PL-490, Title III 1991-1993, Bangladesh Livestock Research Institute, Savar, Dhaka, Bangladesh. pp. 16-42.

Chowdhury, S. A. and K. S. Huque. 1995a. Study on the development of a technique for preserving straw under wet condition in Bangladesh. Paper submitted to the Asian Australsian Journal of Animal Sciences.

Chowdhury, S. A. and K. S. Huque. 1995b. Effect of preserving wet straw with urea on its keeping quality and nutritive value in cattle when supplemented with fish meal. Paper submitted to the Asian Australasian Journal of Animal Sciences.

Chowdhury, S. A., K. S. Huque and M. Khatun. 1995a. Algae in animal Production. Paper presented in the Workshop on 'What kind of Agricultural Science for Development will Account for Biodiversity and Sustainability', held in Copenhagen, Denmark on 3rd to 7th April, 1995.

Chowdhury, S. A., F. D. DeB. Hovell, E. R. Ørskov, J. R. Scaife, G. Mollison and S. Bogoro. 1995b. Protein utilization during energy undernutrition in sheep sustained on intragastric infusion: Effect of changing energy supply on protein utilization. Small Ruminant Research. 18(3):219-226.

Creek, M. J., T. J. Barker and W. A. Hargus. 1984. The development of a new technology in ancient Land. World Animal Review. 51:12-20.

Faichney, G. J. 1986. The kinetics of particulate matter in the rumen. In: Control of Digestion and Metabolism in the Rumen (Editors, L. P. Milligan, W. L. Grovum and A. Dobson). A Reston Book, Prentice-Hall, New Jersey. pp. 173-195.

Leng, R. A. 1984. Microbial interaction in the rumen. In: Ruminant Physiology: Concept and Consequences (Editors, K. Baker, K. M. Gawthorne, J. B. Mackintosh and D. B. Purser). University of Western Australia, Perth. pp. 161-173.

Leng, R. A. 1990. Factors affecting the utilization of 'poor quality' forages by ruminants particularly under tropical conditions. Nutrition Research Reviews, 3: 277-303.

Lobely, G. E. 1990. Energy metabolism reactions in ruminant muscle: response to age, nutrition and hormonal status. Reproduction, Nutrition and Development. 30:13-34.

McDonald, I. 1980. A revised model for the estimation of protein degradability in the rumen. Journal of Animal Science (Cambridge). 96:251-252.

Ørskov, E. R., I. McDonald, D. A. Grub and K. Pennie. 1976. Nutrition of the early weaned lamb. IV. Effects on growth rate, food utilization and body composition changing from a low to high protein diet. Journal of Agricultural Science (Cambridge). 86:411-423.

Ørskov, E. R., F. D. Deb. Hovell and F. D. Mould. 1980. The nylon bag technique for nutritional studies in ruminants. Tropical Animal Production. 5:195-205.

Ørskov, E. R., N. A. MacLeod and Nakashima. 1991. Effect of different volatile fatty acid mixtures on energy metabolism in cattle. Journal of Animal Science. 69:3389-3397.

Perdok, H. B. and R. A. Leng. 1987. Hyperexcitibility in cattle fed ammoniated roughages. Animal Feed Science and Technology. 17:121-143.

Prasad, C. S., K. T. Sampath, M. T. Shivaramaiah and T. K. Walli. 1993. Dry matter intake, digestibility and supplementation of slender and coarse straw - a review. In: Feeding of Ruminants on Fibrous Crop Residues (Editors: K. Singh and J. B. Schere). Indian Council of Agricultural Research, Krishi Bhavan, New Delhi, India. pp. 188-203.

Saadullah, M. 1984. Supplementing ammoniated rice straw for native cattle in Bangladesh. Ph. D. Thesis. The Royal Veterinary and Agric. University Copenhagen, Denmark.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods (6th Edition). Oxford and IBH Publication, Calcutta, India.

Storm, E., E. R. Ørskov and R. Smart. 1983. The nutritive value of rumen microorganisms in ruminants. 2. The apparent digestibility and net utilization of microbial N for growing lambs. British journal of Nutrition. 50:471-478.

Walli, T. K., K. T. Sampath, S. N. Rai and S. Tamminga. 1993. Relevance of RDP/UDP system feeding ruminants in the tropics with special emphasis on straw based diet. In: Feeding of Ruminants on fibrous Crop Residues (Editors: K. Singh and J. B. Schere). Indian Council of Agricultural Research, Krishi Bhavan, New Delhi, India. pp. 157-170.

Webster, A. J. F. 1989. Bioenergetics, bionengineering and growth. Animals production. 48:249-269.

Wilkins, R. J. 1988. The preservation of forages. World Animal Science. B. Disciplinary Approach (Editror, E. R. Ørskov) Elsevier Scientific Publisher, Amsterdam, The Netherlands. pp. 305-339.