STUDY ON THE DEVELOPMENT OF A TECHNIQUE FOR PRESERVING STRAW UNDER WET CONDITION IN BANGLADESH

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Summary

About 7.7 million tons of straw dry matter are being rotten during the monsoon. The objective of this trial was to develop a technique to preserve straw under wet condition. To simulate the moisture content of wet straw, a dry straw was deeped overnight in water. After draining the excess water, the wet straw (668 g moisture kg^{-1}) was divided into twenty fractions and preserved with 0, 30, 50 or 70 g urea kg^{-1} dry matter for either of 30, 60, 90, 120 or 180 days in sealed plastic container. Considering the colour, smell, fungal infestation and pH, the wet straw was preserved excellently up to 180 days when 50 or 70 g of urea per kg DM was used. Urea preservation increased the crude protein contents of straw by 3.6 to 6.4 times (174 to 364 g · kg^{-1}) over that of the dry straw (48 g · kg^{-1}). Although the NDF content of straw was not effected by the level of urea or by the length of the preservation period, but the ADF content increased ($p > 0.05$) by 0.086 to 0.889 g · kg^{-1} straw DM for each g increase in the urea level. At 48 hours, the DM degradibility of dry straw was 350 g · kg^{-1}, which increased to 633 g · kg^{-1} when preserved with 50 g urea kg^{-1} for 180 days. For the same straw, both the rate (0.0388 vs. 0.0136 fraction h^{-1}), the extent (717 vs. 631 g · kg^{-1}) of straw degradation and the estimated ME (9.55 vs. 6.51 MJ · kg^{-1} straw DM) were higher in the preserved than the dry straw.
(**Key Words** : Wet Straw, Preservation, Urea)

Introduction

Total yield of grain of Aus and Boro paddy is about 7.7 million tons (Mahmud et al., 1993) which accounts for about 43% of the total rice grain production of Bangladesh. Considering the straw : grain ratio of 1 : 1 (Chowdhury et al. unpublished), it can be calculated that at least similar amount of straw is also being produced. However, boro and aus crops are harvested during the months of July to August, which is a period of heavy rain fall (337 mm) and very high humidity (86%). Often despite of utmost effort to dry fresh and wet straw by placing it on elevated places like village paths, canal and pond embankments, farmers usually have to conclude their efforts by throwing the straw into compost pits (Hilmersen et al., 1990). Depending on harvesting conditions, 1 kg of freshly cut aus or boro straw typically contains about 400 to 700 g moisture, which together with high humidity (80-90%) provide a suitable media for the microbial and enzymatic degradation of straw. To preserve fresh and wet plant materials, it is necessary to arrest the enzymatic and microbial degradation of structural and non-structural carbohydrates (Wilkins, 1988). This can be achieved by drying or by freezing the materials or by maintaining pH sufficiently low (< 4) or high (> 8). During the monsoon, drying of wet straw is very difficult, and freezing is almost impossible in Bangladesh. As straw contains a very little level of soluble carbohydrate, reduction of pH in the ensiled straw is not possible unless any soluble sugar source, e.g., molasses is being added. However, high pH (> 8) in the ensiled straw can be easily maintained by adding an alkaline substrate like urea, which hydrolyses to NH_3 and may act as preservative. This has distinct advantages over the use of molasses, e.g., (a) it improves crude protein content of the ensiled straw and (b) straw can be ensiled in air tight but not necessarily in an anaerobic condition. Therefore, in the present study, urea has been chosen for preserving wet straw. Tetlow (1983) showed that freshly cut ryegrass (600 g · kg^{-1} DM) can be preserved up to 120 days by storing with urea at the rate of 60 g · kg^{-1} of forage dry matter. The present research program has therefore been undertaken with the following objectives.

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1. Development of a suitable technique for preserving straw under wet condition.
2. Nutritional evaluation of the preserved starw.

Materials and Methods

Preservation method

The experiment was conducted at the end of February, 1993 when no fresh aus or boro straw was available. To simulate the moisture content of wet straw, a dry rice straw (92 g moisture kg^{-1}) was deeped overnight in water and after draining the excess water its moisture content raised to 668 $g \cdot kg^{-1}$. An amounts of wet straw was divided in to twenty fractions each containing 294 g dry matter (DM). A fraction of straw was mixed with any of the four levels of urea e.g. 0, 30, 50 and 70 $g \cdot kg^{-1}$ DM and kept for any of the five preservation period 30, 60, 90, 120 and 180 days in plastic sealed container. The latter condition was maintained inorder to prevent any loss of ammonia liberated from the hydrolysis of urea.

Preservation quality

At the end of each preservation period, the preserved straw was checked for colour, smell, pH and the presence of fungal infestation. Half of the preserved material was then used for chemical analysis and the other half for the dry matter degradability *in sacco*.

Chemical analysis

Both the dry and the preserved straw were analyzed for dry matter (DM), ash, crude protein (CP), neutral detergent fibre (NDF), acid detergent fibre (ADF), lignin and acid insoluble ash according to AOAC (1984). The cell content was estimated from the difference between DM and NDF, while hemicellulose from the difference between NDF and ADF. The CP content of different preserved straw was determined both on fresh (wet) as well as on oven dried(101℃ for 48 h) samples. In both dry and preserved straw, rest of the analyses were done on oven dried ground samples.

Determination of degradation characteristics

Three local bulls each fitted with a 40 mm diameter rumen cannula were used to carry out dacron bag incubation technique as suggested by Ørskov et al. (1980). They were kept in individual pens and offered 3 kg straw, 15 kg green grass and 3 kg concentrate daily. Bags measuring 8 × 13 cm, made of nlyon filter cloth (LT075 Locker Wire Weaver, PO Box 161, Warrington WA1 2SU, U.K.) with pore sizes of 45 to 20 μ were used to incubate the samples. About 1 g of an air dry sample was incubated in the rumen of each cattle. The bags were anchored to a 30 cm plastic tube and withdrawn from the rumen at 0, 8, 16, 24, 32, 48, 72 and 96 hours of incubation. After withdrawal the bags containing the undegraded residues of the samples were washed in running water until the residue was free from dirty water. Dry matter losses were determined for each incubation period and data for each type of preserved straw was described by the exponential equation of McDonald (1981), $p = a + b(1 - e^{-ct})$, where p is the actual degradation at time t and a, b and c are constants. Constant a represents the intercept, b is insoluble but potentially degradable material in time t and c is the rate constant of b. It follows that (a + b) is the total degradability of a straw and is a measure of its nutritive value. In some instances, as will be seen in Table 8, the value of 'a' is negative indicating a lag phase. This will result in an elevated b value but the (a + b) will represent the total potential.

Statistical analysis

There was no replication for the individual treatment. Therefore any effect of the levels of urea or the preservation periods on chemical composition, degradibility or the nutritive value was determined by using the linear regression of the form $y = a + bx$, with appropriate standard error and the level of significance.

Results and Discussion

Preservation characteristics

The changes of physical characteristics and pH related to preservation qualities of straw is shown in table 1. In the absence of urea wet straw became fungal infested with bad pungent smell. When wet straw was stored without urea for 30 or 60 days, microbial fermentation of the structural and non-structural carbohydrate probaly resulted in the reduction of pH (approximately 5). However, with the same treatment but with longer preservation periods (90, 120 or 180 days) the straw had higher pH (7-8) due to unknown reason(s), although they had the same rotten pungent smell as for the straw preserved for shorter period. The fungal growth was arrested by addition of 30 g urea kg^{-1} straw but rotten smell prevailed in it. Irrespective of the duration of preservation periods (30 to 180 days), wet straw mixed either with 50 or 70 g urea per kg was preserved well with strong ammonia smell and had no detectable fungal infestations. This agrees with the observation of Tetlow (1983) who preserved wet ryegrass with urea at 60 $g \cdot kg^{-1}$ and prevented microbial degradation of plant materials.

TABLE 1. PHYSICAL CHARACTERISTICS OF WET STRAW PRESERVED WITH DIFFERENT LEVELS OF UREA FOR DIFFERENT LENGTH OF TIME

Preservation period (days)	Levels of urea	Colour	Smell	Fungated	pH
30	0	Blackish brown	Rotten, acidic	Yes	4.97
	30	Dark brown	Rotten, slightly ammoniated	No	8.41
	50	Yellowish brown	Moderately ammoniated	No	8.45
	70	Blackish brown	Strong ammonia	No	8.71
60	0	Light brown	Rotten, acidic	Yes	5.00
	30	Dark brown	Slightly ammoniated	No	8.69
	50	Brown	Ammoniated	No	8.36
	70	Light brown	Strong ammonia	No	8.27
90	0	Blackish brown	Rotten, pungent	Yes	8.01
	30	Dark brown	Rotten slightly ammoniated	No	8.70
	50	Light brown	Ammoniated	No	8.83
	70	Light brown	Strong ammonia	No	8.80
120	0	Blackish brown	Rotten, pungent	Yes	8.20
	30	Dark blackish brown	Rotten, slightly ammonia	No	8.75
	50	Dark brown	Strong ammonia	No	9.21
	70	Light brown	Strong ammonia	No	9.22
180	0	Brown	Rotten, Pungent	Yes	6.71
	30	Blackish brown	Slightly ammoniated	No	8.95
	50	Blackish brown	Strong ammonia	No	9.46
	70	Balckish brown	Strong ammonia	No	9.42

Chemical composition

The ash, crude protein (CP) and organic matter contents of the preserved straws are presented in table 2. Overnight soaking of the dry straw in water reduced the ash content from 230 $g \cdot kg^{-1}$ to 106 $g \cdot kg^{-1}$ DM. This was probably due to the removal of contaminated soil materials. Implication of these findings is that the digestibility of rice straw, which is largely constrained by the higher silica content (Theander and Aman, 1984), can be improved simply by soaking in water.

Straw preservation with the different levels of urea increased its CP contents by 3.6 to 6.4 folds (174 to 364 $g \cdot kg^{-1}$) over that of the dry straw (48 $g \cdot kg^{-1}$). In all preservation periods, there was a significant ($p < 0.05$) linear increase in CP content with the increase in urea levels (see table 3). However, at a given level of urea, CP content declined (statistically not significant, $p > 0.05$) with the increase in preservation periods (table 4). Another important feature is that when the straw was preserved with different levels of urea and dried afterwards, the CP

TABLE 2. CHEMICAL COMPOSITION ($g \cdot kg^{-1}$) OF DRY AND WET PRESERVED STRAW

Levels of urea ($g \cdot kg^{-1}$ DM)	Preservation period (d)	Ash	Organic matter	Crude Protein[a]	
				Dry	Fresh
0	30	74	926	49	56
	60	84	916	54	62
	90	98	902	72	73
	120	78	922	52	70
	180	94	906	72	54
30	30	67	933	53	185
	60	81	992	68	272
	90	67	933	81	229
	120	79	921	69	188
	180	106	894	117	219
50	30	69	931	60	311
	60	69	931	60	258
	90	70	930	106	307
	120	87	913	67	174
	180	97	903	95	224
70	30	71	929	57	364
	60	66	934	58	339
	90	71	929	83	345
	120	87	929	46	296
	180	95	905	78	249
Dry straw[b]	–	230	704	48	–

[a] Crude protein content of preserved straw either determine after opening of the container (fresh) or determined oven (38°) drying (dry) and hammer milling.

[b] Straw that was used for the experiment.

contents came down to levels almost similar to that of the original dried straw. In feeding ruminants, it would, therefore, be wasteful in terms of CP supply, if the preserved or urea treated straw is dried. The loss of CP content during drying is due to the loss of NH_3 entrapped in to cell wall materials of straw.

The cell wall constituents of dry and preserved wet straw are shown in table 5. The cell wall or NDF (cellulose, hemicellulose and lignin) and ADF (cellulose and lignin) were higher and the cell contents or cell soluble was lower in the preserved straws as compared to that of the dry straw. There were no apparent relationships between the NDF content of the preserved straw with the levels of urea ($p > 0.05$) or the preservation period ($p > 0.05$) (see table 6, 7). There was nonsignificant ($p > 0.05$) positive correlation with the levels of urea and the ADF content of the preserved straw (see table 6). Except the level of 50 g urea kg^{-1}, a non-significant ($p > 0.05$) inverse relationship between the preservation length and ADF content was found at each level of urea inclusion. At 50 $g \cdot kg^{-1}$ urea level there was a significant ($p < 0.05$) increase in ADF content with the increase in preservation period.

At all preservation periods, urea preservation increased the lignin content of straw which is incontrast to the general observation that urea or NH_3 treatment causes solubilization of cell content, hemicellulose and lignin (Theander & Aman, 1984). Increased cell wall constituents (including lignin) and decreased water soluble carbohydrates of urea (60 $g \cdot kg^{-1}$ DM) preserved rye grass has been reported by Tetlow (1983). This is

TABLE 3. REGRESSION BETWEEN THE LEVELS OF URES (0, 3, 5 AND 7% OF STRAW DM) AND THE CRUDE PROTEIN CONTENT (%) OF THE FRESH OR THE OVEN DRIED (101℃ FOR 48 HOURS) STRAW PRESERVED FOR DIFFERENT LENGTH OF PERIODS

Preservation period (d)	Condition	No of Obs.	a	r	b	Significance of b	
						SE	Level
30	Fresh	4	5.719	0.990	4.581	0.417	0.01
	Oven dry	4	4.960	0.867	0.136	0.055	NS
60	Fresh	4	9.464	0.925	3.694	1.072	0.05
	Oven dry	4	5.866	0.190	0.038	0.137	NS
90	Fresh	4	9.022	0.982	3.963	0.538	0.05
	Oven dry	4	7.549	0.549	0.267	0.278	NS
120	Fresh	4	2.910	0.937	2.910	0.767	0.05
	Oven dry	4	6.077	0.147	−0.057	0.271	NS
180	Fresh	4	8.55	0.903	2.719	0.193	0.05
	Oven dry	4	8.83	0.082	0.056	2.470	NS

TABLE 4. REGRESSION BETWEEN THE PRESERVATION PERIODS (0, 30, 60, 90, 120 AND 180 D) AND THE CRUDE PROTEIN CONTENT OF WET STRAW PRESERVED WITH DIFFERENT LEVELS OF UREA

Urea level ($g \cdot kg^{-1}$ straw DM)	Number observation	a	r	b	Significance of b	
					SE	Level
0	5	6.42	−0.080	−1.220	0.008	NS
30	5	22.19	−0.055	−3.429	0.036	NS
50	5	31.6	−0.630	−0.060	0.057	NS
70	5	39.33	−0.964	−0.077	0.012	NS

TABLE 5. CELL WALL CONSTITUENTS AND CELL CONTENTS OF THE DRY AND PRESERVED STRAW ($g \cdot kg^{-1}$)

Urea level ($g \cdot kg^{-1}$ DM)	Preservation period (d)	NDF	ADF	Hemicellulose	Cell content	Lignin	Insoluble ash
0	30	778	488	289	222	61	45
	60	774	538	307	226	102	54
	90	822	508	390	178	201	50
	120	735	468	258	265	113	44
	180	766	489	279	234	99	44
30	30	751	485	266	249	77	47
	60	730	538	192	270	123	60
	90	756	508	248	244	168	51
	120	789	468	320	211	99	51
	180	690	490	201	310	66	47
50	30	797	476	321	203	53	76
	60	797	523	274	203	101	55
	90	836	535	299	166	185	57
	120	712	531	180	288	101	71
	180	700	582	224	300	112	46
70	30	743	499	244	257	132	48
	60	748	579	170	252	128	54
	90	772	542	230	228	102	26
	120	772	517	255	228	76	69
	180	745	522	266	255	112	46
Dry straw	−	713	472	241	297	62	46

TABLE 6. REGRESSION BETWEEN THE LEVEL OF URES (X) AND THE LEVEL OF NDF OR ADF CONTENT (Y) OF STRAW FOR DIFFERENT LENGTH OF PERIODS

Dependent variables (Y)	Preservation period (d)	No.of Obs	a($g \cdot kg^{-1}$)	r	b($g \cdot kg^{-1}$)	Significance of b	
						SE	Level
NDF	30	4	777	0.313	−0.261	0.559	NS
	60	4	774	0.086	−0.085	0.693	NS
	90	4	809	0.277	−0.357	0.876	NS
	120	4	744	0.163	0.190	0.816	NS
	180	4	738	0.209	−0.350	0.821	NS
ADF	30	4	484	0.271	0.086	0.216	NS
	60	4	528	0.531	0.428	0.483	NS
	90	4	508	0.552	0.236	0.251	NS
	120	4	462	0.809	0.889	0.457	NS
	180	4	489	0.570	0.833	0.849	NS

probably due to the increase in the acid detergent insoluble N (ADIN) content of urea/NH_3 treated straw than the untreated straw (Walli et al., 1993), resulting in the over estimation of lignin content in the former.

Degradation characteristics

The degradation characteristics of the dried and preserved straw are given in table 8. The 48 h dry matter loss (DBL) of a straw is used mainly to illustrate the

TABLE 7. REGRESSION BETWEEN THE PRESERVATION PERIODS (X) AND NDF OR ADF (Y) CONTENT OF STRAW PRESERVED WITH DIFFERENT LEVELS OF UREA

Dependent variable (Y)	Levels of urea ($g \cdot kg^{-1}$)	No.of Obs	a	r	b	Significance of b	
						SE	Level
NDF	0	5	790	0.299	−0.162	0.216	NS
	30	5	768	0.414	−0.262	0.332	NS
	50	5	843	0.761	−0.782	0.385	NS
	70	5	752	0.150	0.038	0.146	NS
ADF	0	5	515	0.380	−0.174	0.244	NS
	30	5	512	0.331	−0.153	0.251	NS
	50	5	470	0.939	0.612	0.130	$p < 0.05$
	70	5	537	0.110	−0.058	0.303	NS

TABLE 8. DRY MATTER LOSS (DBL) ON INCUBATION IN THE RUMEN OF STRAW PRESERVED WITH DIFFERENT LEVELS OF UREA, FOR DIFFERENT LENGTH OF PERIODS. THE FACTORS OF EXPONENTIAL EQUATION $p = a + b(1 - e^{ct})$ DESCRIBING DEGRADATION (p) WITH TIME (t)

Preservation period (d)	Levels of urea ($g \cdot kg^{-1}$)	DBL 48 h incubation $g \cdot kg^{-1}$	a ($g \cdot kg^{-1}$)	b ($g \cdot kg^{-1}$)	c (fraction h^{-1})	Asymptote a + b ($g \cdot kg^{-1}$)	Residual S.D ($g \cdot kg^{-1}$)
Original Straw (O)		350	48	631	0.0136	679	39.6
30	0	342	40	692	0.0120	732	31.9
	30	403	−9	678	0.0195	669	38.9
	50	447	16	507	0.0394	667	14.1
	70	548	100	573	0.0310	673	52.8
60	0	277	20	355	0.0305	355	49.2
	30	350	48	632	0.0136	680	39.6
	50	573	120	539	0.0385	659	48.1
	70	450	11	716	0.0198	727	40.4
90	0	250	30	355	0.0201	385	23.1
	30	420	−2	632	0.0230	630	36.3
	50	491	99	567	0.0245	666	38.5
	70	511	34	669	0.0260	703	30.5
120	0	292	−59	507	0.0245	448	19.9
	30	388	117	568	0.0135	685	31.2
	50	590	42	777	0.0254	819	53.2
	70	512	91	654	0.0215	745	41.1
180	0	299	−4	605	0.0144	601	22.3
	30	404	−34	684	0.02130	650	43.5
	50	633	28	717	0.0388	745	57.4
	70	539	−2	831	0.02201	829	27.7

ranking of straw qualities (Ørskov et al., 1990). When incubated for 48 h, the straw that was preserved without urea (0 g · kg^{-1}) for different period of time, had low DBL than that of the straw orignially used for preservation. This is probably due to the loss of soluble material in water during soaking. However, when preserved with urea, 48 h DBL were always higher in the preserved straw than the dry straw (see table 8). At different preservation periods, the correlation coefficients between the levels of urea and 48 h DBL were not significant ($p > 0.05$) except up to 30 days preservation. It was probably due to fewer number of observation (see table 9). However, there was an increasing tendency of 48 h DBL with the increase in urea levels. Very poor correlation coefficient between the preservation periods and 48 h DMLs or degradation rate constants (c) or total degradabilities (A + B) suggest that none of the degradation characteristics were affected by the length of preservation. Higher degradation of urea preserved straw is probably due to the greater accessibility of hydrolytic enzyme to fibrous material as a result of the solubilization of hemicellulose and lignin by the NH_3 (Chesson and Ørskov, 1990). Another possibility is that urea preservation increases the availability of the rumen NH_3-N to microbes which is a major constraint to straw degradation, and might have increased the microbial fermentation of straw.

The degradation rate (c) of straw was always higher when preserved with urea at 50 g · kg^{-1} than the straw preserved either with a high or low levels of urea. The importance of straw degradation rate to the host animal is that it determines the speed at which the digestible component are removed from the feed and thus its retention time in the gut is reduced (Chesson & Ørskov, 1990). As the intake of straw is limited by the physical size of the gut, faster degradation rate may give higher intake and high ruminal turnover (Sundstol, 1988) and may increase microbial protein productions (ARC, 1984). Chesson and Ørskov (1990) have shown that two different types of straw might have the same potential degradability but the one with higher degradation rate is more desirable than the other. There were no significant ($p > 0.05$) relationships between the degradation rate (c) and the levels of urea used or the length of the period preserved (see table 10). Similarly, relationship between the potential degradabilities (a + b) and urea levels or preservation periods were also not significant ($p > 0.05$). This suggests that neither potential degradabilities (a + b) nor degradation rate (c) were affected by the change in urea levels used or by the length of the period preserved. Therefore, as far as nutritive value is concerned, preservation of wet straw with 50 g urea kg^{-1} straw DM is more desirable than the other levels.

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TABLE 9. REGRESSION BETWEEN THE LEVELS OF UREA (X) AND 48 h DRY MATTER LOSS (DBL) OR RATE CONSTANT (c, FRACTION PER HOUR) OR TOTAL POTENTIAL DEGRADABILITY (a + b) (Y) OF STRAW PRESERVED FOR DIFFERENT LENGTH OF PERIODS

Dependent variables (Y)	Preservation period(d), (X)	No.of Obs	a	r	b	Significance of b	
						SE	Level
48 h DBL	30	4	329	0.971	2.82	0.488	$p < 0.05$
(g · kg^{-1})	60	4	289	0.763	3.28	1.964	NS
	90	4	275	0.962	3.82	0.769	NS
	120	4	303	0.856	3.796	1.595	NS
	180	4	311	0.849	4.182	1.841	NS
Rate	30	4	0.0128	0.831	0.000337	0.000159	NS
constant (c)	60	4	0.0273	0.122	−0.00004	0.00026	NS
	90	4	0.0202	0.997	0.000084	0.00004	$p < 0.01$
	120	4	0.0213	0.008	−0.00000	−	NS
	180	4	0.0171	0.539	0.000187	0.000206	NS
a + b	30	4	717	0.806	−0.84	0.438	NS
(g · kg^{-1})	60	4	417	0.887	5.03	1.848	NS
	90	4	426	0.932	4.49	1.231	NS
	120	4	499	0.870	4.68	1.871	NS
	180	4	582	0.974	3.31	0.544	$p < 0.05$

TABLE 10. REGRESSION BETWEEN THE PRESERVATION PERIOD (X) AND 48 h DRY MATTER LOSS (DBL) OR RATE CONSTANT (c, FRACTION PER HOUR) OR TOTAL POTENTIAL DEGRADABILITY (a + b) (Y) OF STRAW PRESERVED WITH DIFFERENT LEVELS OF UREA

Dependent variable (Y)	Levels of urea($g \cdot kg^{-1}$)	No.of Obs	a	r	b	Significance of b	
						SE	Level
48 h DBL	0	5	306	0.246	−0.144	0.326	NS
($g \cdot kg^{-1}$)	30	5	382	0.249	0.115	0.257	NS
	50	5	444	0.813	1.070	0.442	NS
	70	5	496	0.241	1.600	0.372	NS
Rate	0	5	0.0218	0.123	−0.00001	0.000074	NS
constant (c)	30	5	0.0167	0.195	0.000014	0.000043	NS
	50	5	0.0352	0.149	−0.00001	0.000075	NS
	70	5	0.0280	0.530	−0.00004	0.000038	NS
a + b	0	5	520	0.059	−0.16	1.586	NS
($g \cdot kg^{-1}$)	30	5	672	0.262	−0.10	0.219	NS
	50	5	635	0.651	0.79	0.529	NS
	70	5	644	0.935	0.95	0.209	$p < 0.05$

TABLE 11. THE ESTIMATED METABOLIZABLE ENERGY (ME MJ/kg DM)[a] AND THE MICROBIAL N (MN G/kg DM)[b] CONTENTS OF DIFFERENT PRESERVED STRAW

Preservation Period (Days)	Levels of Urea	48 h Degradibility (%)	ME (MJ/kg DM)	MN (g/kg DM)
Original Straw	–	35.0	6.512	6.512
30	0	34.2	6.426	6.426
	30	40.3	7.080	7.080
	50	44.7	7.552	7.552
	70	54.8	8.636	8.637
60	0	27.7	5.728	5.728
	30	35.0	6.512	6.512
	50	57.3	8.904	8.904
	70	45.0	7.585	7.585
90	0	25.0	5.439	5.439
	30	42.0	7.262	7.262
	50	49.1	8.024	8.024
	70	51.1	8.239	8.239
120	0	29.2	5.889	5.889
	30	38.8	6.919	6.919
	50	59.0	9.087	9.087
	70	51.2	8.249	8.249
180	0	29.9	5.964	5.964
	30	40.4	7.090	7.090
	50	63.3	9.548	9.548
	70	53.9	8.539	8.539

[a] Me ($MJ \cdot kg^{-1}$ DM) = 2.756 + 48 h DM degradibility (%) × 0.1073 (Personal communication, E. R. Ørskov, The Rowett Research Institute, UK).

[b] MN ($g \cdot kg^{-1}$ DM) was estimated as 1 g MN · MJ^{-1} ME (ARC, 1980).

K. (E. R. Ørskov, personal communication) have shown that the 48 h DBL (%) is closely related to the metabolizable energy (ME) content, and the relationship has been expressed as:

ME ($MJ \cdot kg^{-1}$ DM) = 2.756 + 48 h DBL % × 0.1073

The estimated (from the above equation) ME ($MJ \cdot kg^{-1}$ DM) and the microbial N (MN $g \cdot kg^{-1}$ DM) yield (assuming 1 g MN · MJ^{-1} ME; ARC, 19080) of different preserved straw are shown in table 11. The estimated ME content of the straw preserved with 50 $g \cdot kg^{-1}$ urea for 180 days, was 9.55 MJ ME · kg^{-1} DM and the corresponding MN yield was 9.55 $g \cdot kg^{-1}$ DM. It can then be calculated that the urea-preservation of 7.7 million tons of aus and boro straw, which otherwise being wasted, can contribute 73535 million MJ of ME and 73.535 million kg microbial N (or 459.6 million kg microbial protein). Therefore preservation of fresh and wet straw during monsoon, can alone can meet up the present deficit of ME and CP (see Huque et al., 1992) requirements of ruminant animals in Bangladesh.

From the above experiment it may be concluded that wet straw can be preserved with 50 to 70 g urea kg^{-1} straw DM under air tight conditions for a period of as long as six months. However, 50 g urea kg^{-1} straw DM found to be the best in all respects. Such preservation improves the nutritive value of straw by increasing the crude protein and also the rate and extent of DM degradation in the rumen. However, the present experiment was conducted under controlled laboratory condition. Therefore, large scale on-station and on-farm trials are essential to ascertain the laboratory findings.

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