EFFECTIVENESS OF AMMONIFICATION THROUGH UREA IN IMPROVING THE FEEDING VALUE OF RICE STRAW IN RUMINANTS

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Eight male crossbred sheep with four in each batch were used to provide backup research for an integrated rural development project.

The crude protein (CP) content of rice straw tree increased from 2.9% through various treatments with urea as follows: 3% and 5% urea in an earthen pit for 20 days, 5.9% CP and 6.7% CP respectively; 5% urea in an earthen pit for 40 days, 6.5% CP; 5% urea in a bamboo basket for 20 days, 7.1% CP. The intake of organic matter rose from 46.2g/kg $W^{0.71}$/day. in untreated straw, to 51.7 with 3% urea. 60.9 with 5% urea treated for 20 days and 63.4 when treated with 5% urea for 40 days and fed 10% molasses ant 57.5 for straw treated with 5% urea in a bamboo basket. The organic matter and crude fibre digestibility increased from 45% and 65% in untreated straw to 54 and 65 with the 3% urea treatment, 56 and 60, 57 and 60 in straw treated with 5% urea and fed without and with 10% molasses and 56% and 64% in straw treated with 5% urea in a bamboo basket. The-nitrogen balance was found to be positive in the treatments with 5% urea.

Calculated metabolizable energy MJ/kg DM increased from 6.93 in untreated straw to a maximum of 9.51 in straw treated with 5% urea and fed with 102 molasses.

It is concluded that treatment of rice straw with ammonia through urea is possible under simple storage conditions. This is an essential step in bringing the method to the use of small farmers. Further studies are recommended.

Key words: Rice straw, urea, ammonification, sheep, digestibility

Recently a good number of studies have been conducted to measure the influence of mechanical and chemical treatments on the digestibility and metabolizable energy value of different types of straw. Of the chemicals used, NaOH is found to be exceedingly effective, but it has become expensive, it is difficult to get in Bangladesh and it is difficult to handle.

Most of the work on the treatment of straw with either NaOH or NH has recently been reviewed by Jackson (1978) and Sundstol et al (1978). But the treatment of straw with anhydrous or liquid ammonia is also a problem for those areas where it is not available. Even if it was, lack of roads would make transport of equipment difficult.

Jackson (1978) reviewed the literature on ammonification of straw through urea either using high temperatures during a pelleting process or by the action of a urease enzyme in a silo. Oji and Mowat (1977) used urea as a source of ammonia with corn stover and observed chat urea was broken down to ammonia after 20 days. The stover contained from 55% to 65% dry matter and already after 2 days 70% of the urea was broken down to ammonia. This was at room temperature.

Treatment with ammonia has some advantages over NaOH. After treatment excess ammonia evaporates, while ammonia bound to the straw during treatment can serve as a source of nitrogen for microbial protein synthesis in the rumen. Ammonia is also a good fungicide and freshly harvested straw can be preserved by ammonia treatment during the monsoon season. Coxworth and Kullman (1978) preserved 37%

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moisture green Harmon oats for 60 days without spoilage with 5.3% urea. Digestibility in vitro increased from 47% to 53%, and- protein content from 11.1% to 16%. Increased apparent digestibility of dry and organic matter of roughages treated with ammonia was also observed by Oji and Mowat (1979) and Garret et al (1979). Many workers have confirmed the effect of urea and ammonia treatment on increasing intake of straw. (Lawlor and O'Shea 1979; Gadre 1980; Rashiq 1980).

The objective of the Present work was to provide/backup research for the Integrated Rural Development Project with Danish Assistance in Noakhali District in Bangladesh, in order to observe the effectiveness of ammonification through urea on rice straw either dry or freshly harvested on increased feed intake, digestibility and nitrogen retention.

Efforts were also made to find a suitable treatment technique for village conditions.

Materials and Methods

Straw treatment: (a) Earthen pit. Earthen pits measuring 4m x 3m and 1.5m deep were dug in the University farm yard. The pits were plastered with a mixture of mud and cow dung inside and then lined with banana leaves to avoid spoilage of straw, Freshly harvested rice straw with 55% moisture was put into the pits while urea was applied at the rate of 30 and 50 g per kg of straw layer by layer. The pit was covered with bamboo mats and a 16 cm layer of mud was placed on top of the mats. The pits were opened after 20 and 40 days. The straw was dried in the sun and fed to the experimental sheep.

(b) Bamboo basket: A bamboo basket with a capacity of 100 kg of straw was plastered with a mixture of mud and cow dung and lined with banana leaves and used as a silo for treating straw. The top was covered with hessian which was also plastered with a mixture of cow dung and mud. As this was dry straw, the 5% urea was dissolved in an amount of water of the same weight as the straw treated. The basket was opened after 20 days and the straw was dried and fed to the experimental sheep.

Digestion trial: Eight male crossbred sheep were used for a digestion trial with 4 sheep in each group. Sheep within a group were of similar weights.* Due to a limited number of sheep and lack of skilled manpower, trials were not run simultaneously. Each sheep was placed in a specially designed digestion trial crate with a 15 day preliminary period followed by a 7 day collection period. As the same sheep had been used to determine digestibility of straw treated in different ways during the preceding half year, they were well adjusted to straw.

The straw was given ad libitum and intake measured daily. Faeces and urine were collected daily for 7 days. A representative sample of feed and faeces were analysed for DM, OM, CP, CF and ash. The urine was preserved with 6N HC1 and analysed for total nitrogen by the conventional Kjeldhal method. Analysis of variance was used to determine the effect of treatment and Duncan's multiple range test for significance.

Results and Discussion

The chemical composition of ammoniated rice straw is shown in Table 1. The treated samples had a lower dry matter than the untreated straw.

* See Editors' note at the bottom of the following page.

Table 1:
Chemical composition of rice straw (g per 100 g of DM)

	Dry matter	Crude protein	Crude fibre	Ash
Untreated rice straw	89	2.9	28	11
Freshly harvested rice straw ammoniated with 3% urea in earthen pit for 20 days	80	5.9	25	10
Freshly harvested rice straw ammoniated with 5% urea in earthen pit for 20 days	84	6.7	24	11
Freshly harvested rice straw ammoniated with 5% urea in earthen pit for 40 days	83	6.5	24	12
Dry rice straw ammoniated with 5% urea in bamboo basket for 20 days	85	7.1	26	12

Treatment of straw with urea increases the crude protein content of the straw by a factor of 2 to 2.5. This is still only around 30% to 35% of the ammonia added to the straw during treatment, and it will be important in future work to try to devise methods of recapturing this lost ammonia. Still the present results on increase in nitrogen content are in agreement with Waiss et al (1972), Waegepetersen and Thomsen (1977) and Rashiq (l980), but the values are low. Treating rice straw for 30 days with 5% aqueous ammonia, Waiss et al (1972) increased the nitrogen content of rice straw by 133% but crude protein was still only 8.3%, lower than values for other types of straw in the same study. As rice straw is cultivated in areas of the world where the supplementation with protein is relatively expensive as most of the land is under cereal cultivation, it would be important to determine the causes for this poor level of nitrogen fixation.

The crude fibre fraction has been reduced by 2% to 4 % units due to treatment of the straw.

Feed intake: The figures in Table 2 reveal a considerable increase in

Table 2: *
Voluntary intake of rice straw ammoniated through urea by different methods

	Untreated rice straw	3% urea treated in Earthen pit	5% urea treated in Earthen pit	5% urea treated in Earthen pit 40 days 10%molasses	5% urea treated in bamboo basket
Dry matter intake (g/d)	369	547	641	484	606
Organic matter intake (g/d)	324	489	567	428	537
Average weight of animals, kg	13.5	20.1	19.5	12.7	20.0
Consumption index[1]	2.7	2.7	3.3	3.8	3.0
Organic matter intake (g/kg $W^{0.75}$/day)	46.2	51.7	60.9	63.4	57.5
Metabolizable energy concentration (ME) (MJ/kg DM)	6.9	7.8	9.1	9.5	8.6

[1] Intake of DM/100 kg liveweight

* Editors note: The editor would like to draw attention to the large bodyweight difference between treatment groups and the possible effects of this on intake and digestibility.

intake due to treatment, when comparisons of DM and OM are made both in terms of both kg $W^{0.75}$ and 100 kg liveweight. A statistical analysis yielded significance at .01 level, when intake of organic matter of untreated straw treated was compared to the treated.

A high level of intake of dry matter is a first condition for production. Experimenting with a diet of 90% rice straw on a dry matter basis, Davis and Khan (1980) found an intake range/100 kg liveweight from 2.6 to 3.1 kg DM in native Bangladesh cattle. In their preliminary work on straw treatment under village conditions in Bangladesh Ahmed and Dolberg (1979) observed a similar range, also in a diet of 90% straw on a dry matter basis.

Treatment of straw increases the metabolizable energy concentration (ME) in terms of MJ/kg DM (calculated according to Technical Bulletin No.33 MAFF, 1975). Assuming 5 MJ/kg of milk and 34 MJ/kg of liveweight gain, diet in Table 2 of 5% urea treated straw supplemented with 10% molasses at the time of feeding would permit for a production of either 9 kg of milk or a 1.35 kg gain of a 200 kg animal. This would of course require proper mineral and protein supplementation. The figures are very high. A vigorous production trial programme is called for to determine the production to be had and also to identify possible smaller limiting nutrients.

The increase in intake due to straw treatment is in line with results reported by Horton (1978), Garret et al (1979) and Oji and Mowat (1979). Lawlor and O'Shea (1979) observed this effect to be highly significant ($P < 0.01$). Rashiq (1980) also observed a significant effect on feed intake when straw was treated with urea. Other workers used ammonia directly.

Digestibility: Digestibility of dry matter, organic matter and crude fibre is shown in Table 3.

Table 3:

Apparent digestibility and nitrogen retention of rice straw ammoniated through urea by different methods

	Untreated rice straw	3% urea treated (Earthen pit) for 20 days	5% urea treated (Earthen pit) for 20 days	5% urea treated (Earthen pit) for 40 days fed with 10% molasses	5% urea treated in bamboo basket for 20 days
Dry matter	40	51	54	55	52
Organic matter	45	54	56	57	56
Crude fibre	56	65	60	60	64
N retention, g/d	-2.5	-1.34	+0.2	+0.34	+0.4

For dry matter the range in increase is from 11 to 15% units, while it is from 9 to 12% units in organic matter, when untreated straw is compared to treated. Among the treatments, 3% urea gave poorer results than 5% urea, while treatment in earthen pits again has given a better result than the bamboo basket. In all cases treated gave highly significant result, ($P < 0.01$) over untreated . The same was the case with the digestibility of crude fibre. But as trials were not run simultaneously, more complex analysis within trials were not attempted. However, for the same reasons a comparison with other works where straw was treated with urea as the source of ammonia is made in Table 4.

Table 4:

Comparison of works, where straw was treated with urea as a source of ammonia

Testing method	Level of urea %	Straw	Digestibility % Untreated	Treated	Increase in digestible DM intake, %	Reference
In vitro	5	Rice	35.2	52.3	-	Ahmed (1980)
Nylon bag						
72 hours	4	Wheat	55.0	65.0	-	Gadre (1980)
In vivo	4	Wheat	42.5	42.8[a]	66	" "
In vivo	5.3	Wheat	41.8	54.0[b]	37	Rashiq (1980)
In vivo	5.3	Wheat		50.5[a]	93	" "
In vivo	5	Rice	40.8	54.0[a]	59	Present work
				52.4[a]	42	" "
				54.9[a,c]	89	" "

[a] Feeding ad libitum.

[b] Feeding restricted to level of intake of untreated

[c] 10% molasses added at time of feeding

Table 4 reveals that urea treatment typically increases DM digestibility by 10% to 15% units. The values of this study fall well within this range. The table also shows that urea treatment has a very strong positive effect on digestible dry matter intake. The work of Rashiq (1980) demonstrates a 37% increase, when straw is fed at the same level as the control group but 93% when the animals were allowed to eat ad libitum. This caused the classical depression of digestibility from 54.0% to 50.5%. This is probably the same effect as observed by Gadre (1980) where there was no change in digestibility in vivo, but a 66% increase in intake.

The addition of 10% molasses at the time of feeding did not cause any significant increase in digestibility but intake showed a significant ($P < .01$) increase when compared to any of the other diets.

As the control trial was run in the beginning of a series of trials it might be suspected that the higher intake level on treated straw was caused by the sheep getting adjusted to the straw. For this reason a new trial on untreated straw was run after the work presented here was over. A comparison is made in Table 5. From the table it appears that in spite of 8 months of continuous feeding on straw, intake and digestibility is immediately depressed when untreated straw is fed.

Table 5:

Comparison of two trials on untreated rice straw

Trial	Average weight of sheep, kg	Dry matter intake ($g/kg\ W^{0.75}/day$)	Dry matter digested, %	Nitrogen balance g/24 hours
Ante	13.5	52.4	40.8	- 2.5
Post	21.5	53.8	37.9	- 2.9

N retention: Due to ammonification through urea the nitrogen balance of the animals is improved, as is apparent from Table 3. The increase from -2,5 g in untreated straw to - 1.34 in 3% treated straw to +.20, +.34 and +.40 in 55 urea treated straw, is quite consistent with the increase in level of urea but does not agree with the low increase in crude protein, when going from 3% to 55 urea in Table 1.

However as ammonia is both easily soluble in water and easy to remove by heat (Ranche-Madsen 1972), a possible explanation is that half of the ammonia is removed during drying in the oven before it is subjected to analysis.

Treatment Method:

Earthen pit: Straw ammoniated with 3% urea did not give as strong a smell of ammonia as straw treated with 5% urea, when the pit was opened. The temperature in the pit on the second day of ensilement was 35°C. This rose to 45°C ± 5°C during the subsequent 18 days. Above 30°C, Sundstol et al (1978) reported that one week of treatment is sufficient.

There was no apparent loss of straw with any of the treatments. The moisture content of the straw after the pit was opened was 47 + 3% in the straw treated with 3% urea Rashiq (1980) found 65%-moisture quickened the process of urea breakdown to ammonia, when he compared it to 40% and 15% moisture. He also found 3.3% urea at a 65% moisture level as efficient as 5.4% urea at 40% moisture level at temperatures of 20°C and 30°C in terms of increasing organic matter fermentability in vitro. This was over periods of 3, 6 and 9 weeks. Waiss et al (19/2) and Sundstol et al (1978) have also demonstrated advantages of higher moisture level, but at lower levels and not with urea as a source of ammonia. Because of the two-tier system in the use of urea , the question deserves further attention. Particularly if more water saves urea.

As straw was well preserved in this experiment in spite of a high moisture level, it is suggested straw harvested during the monsoon season could be ensiled with an addition of urea, if water could be prevented from entering the pit.

It was observed to be important to put fresh banana leaves along the sides of the pit during each new ensiling. Otherwise there was a tendency for fungi to develop at the sides.

Bamboo basket: This technique was found to be quite satisfactory for small quantities of straw, easy to handle and involving only low cost. Temperature can be increased by putting it in the sun. The moisture content of the straw was found to be 40 ± 5%.

Conclusion

As values reported in this study are similar to those obtained where airtight containers were used, it is concluded that treatment of straw with ammonia through urea is possible under simple storage conditions which is an essential step in bringing the method to the use of small farmers.

As suggested in this study also, the theoretical production potential of a treated straw based diet is considerable.

Further studies are needed. From a small holder/subsistence farmer point of view, it is important to carry out production experiments where straw constitutes no less than 80% to 90% of the total dry matter in the diet.

It is proposed the work on utilization of straw and other low quality roughages cc could branch into animal breeding in an effort to breed animals with highest possible production potential from a straw diet.

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On completion of the paper, Dr Orskov, the Rowett Research Institute, Scotland, informs that experimenting on Friesian heifers fed NH_3 treated straw alone, they observed gains from 350-400 g/day, while the control group on untreated straw, but fed a urea supplement at the time of feeding lost a similar amount. Intake increased by 50%. This trial has just been finished.

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