Pakistan Journal of Nutrition 2 (3): 153-158, 2003

Nutritive Value of Damp Rice Straw and its Feeding Effect on Aflatoxin Transmission into Cows Milk

A. Bhuiyan, M. A. Akbar and M. E. Hossain
Department of Animal Nutrition, Bangladesh Agricultural University, Mymensingh, Bangladesh
E-mail: bhuiyanaa@yahoo.com

Abstract: The experiment was carried out to determine the nutritive value of different level of fermented rice straw as well as to detect the level of mycotoxin contamination and its transmission into cow's milk. Rice straw was collected from selected area based on degree of fermentation i.e. high fermented, low fermented and unfermented rice straw. Similarly, milk samples were collected from cows fed rice straw of the same area. Results showed that, DM, CF and NFE were significantly ($P<0.05$) lower in high fermented rice straw compared to low and unfermented straw. The *in vitro* digestibility of OM of high fermented rice straw were significantly ($P<0.01$) lower than unfermented straw (40.69 vs. 41.55%). However, ME content of rice straw was similar ($P>0.05$) irrespective of level of fermentation. The effective degradability of DM for high fermented straw was significantly ($P<0.05$) lower than unfermented straw (13.03 vs. 19.26%). However, the effective degradability of CP of high fermented straw was significantly ($P<0.05$) higher than unfermented straw (17.10 vs. 10.83%). Chemical analysis of fermented and unfermented rice straw did not show detectable level of aflatoxin. However, milk samples collected from some area showed certain level of aflatoxin M_1 (0.001 µg/kg to 0.006 µg/kg). These findings clearly show that, fermentation of rice straw due to dampness reduces its soluble nutrients, *in vitro* digestibility and degradation of DM *in situ,* however, increases the effective degradability of CP. Dampness also leads to the transmission of aflatoxin M_1 from fermented straw to cow's milk in low level.

Key words: Cow, rice straw, nutritive value, aflatoxin

Introduction

In Bangladesh, livestock, specially ruminants, largely depend on agro-industrial byproducts particularly, rice straw. Since the production of rice straw is seasonal, the farmers traditionally store it for several months to feed their animals. There are mainly two seasons in a year i.e. dry season and monsoon. Monsoon launches in July and continues up to October. This period accounts for 80% of the total rainfall which tremendously affects the existing practice of storing straw (BBS, 1999). As the farmers are not conscious enough for storing straw, so there is always certain amount of losses of straw through different routes of which the most common is rain-damage. The farmers reported that, under normal rainfall, the damage of straw due to rain and wet weather was 50%, however, if there was persistently heavy rainfall, the damage ranged from 80-85% (Mamun, 2001). For Aus and Boro straw, the magnitude of damage is very high as there is insufficient sunshine and this is the most important reason for why straw starts fermenting due to heat generation leading to moulds growth and making it unpalatable for cattle and buffaloes. The generation of heat may initiate some chemical changes in straw that might affect its feed value. The moulds, wherever it grow, produce toxin (Coker, 1999) which is termed as mycotoxin. Therefore, it is very likely that mouldy straw would be contaminated with mycotoxin (Coker, 1979). Mycotoxin occurs in a wide variety of feeds and have been implicated in a wide range of human and animal diseases (Coker, 1979). There are over 200 known mycotoxins and aflatoxin is one of them produced by *Aspergillus flavus* and *Aspergillus parasiticus.* The most important point of worrying is that aflatoxin can be transmitted from feed to milk of dairy cows and results in toxic and carcinogenic effects (Jones and Coker, 1994) on human, particularly babies consuming milk. Under above context, present research was conducted to find out the nutritional quality of fermented rice straw, the presence of aflatoxin and its transmission to cows milk.

Materials and Methods

Collection and sampling of rice straw: The experiment was conducted in four villages of Mymensingh district (Rajpur and Garaikuthi in Muktagacha Upazilla and Motbari and Bharadova in Trishal Upazilla). Samples collected from roofed store were treated as control (unfermented) and those collected from traditional storage system were treated as high and low fermented straw according to their degree of fermentation. After collection, straw was chopped to 3-4 cm size, exposed to sun drying and ground to 2-3 mm size for chemical analyses.

Collection and sampling of milk for analysis: Milk samples (250 ml) from five cows fed on each type of rice straw (high, low and unfermented) were collected, mixed and pooled to one sample for each treatment. The pooled samples were then freeze-dried to make powder and were sent to Natural Resources Institute (NRI), UK for mycotoxin analysis. The method followed was that of Bradburn *et al.* (1990).

Chemical analysis, *in vitro* digestibility and energy content of rice straw: The chemical analyses of different straw samples were done in the Animal Nutrition Laboratory at the Bangladesh Agricultural University. Proximate components such as dry matter (DM), crude protein (CP), crude fiber (CF), ash, ether extract (EE) and nitrogen free extract (NFE) were determined as per AOAC (1990). Similarly, *In vitro* digestibility and metabolizable energy (ME) value rice straw was done by using the procedure of Hohenheim Gas Test (Menke and Steingass, 1988). of different rice straw samples was also determined from Gas production and proximate value.

In situ nylon bag study and calculation of degradability of straw: Three adult cannulated steers were used for studying degradability of three types of rice straw in a 3×3 Latin Square Design. The ruminal degradability of DM and CP for three samples of rice straw were determined by *in situ* nylon bag technique (Mehrez and Orskov, 1977). The results of dry matter (DM) and crude protein (CP) disappearance were fitted to the following exponential models of Orskov and McDonald (1979) and the degradation were calculated by using the NAWAY computer programme with the following exponential model:

$$P = a + b\ (1 - e^{-ct})$$

Where, P = Percentage disappearance at time t
a = Rapidly soluble fraction
b = Slowly degradable fraction
a + b = Potential degradability
c = Fractional rate constant at which b will be degraded.
t = Time.

Effective degradability of DM and CP were calculated from the rumen outflow rate (K_P) and the constants 'a', 'b' and 'c' from the above model. `K_P' was calculated on 0.05 per h. The effective degradability of dry matter (EDDM) and crude protein (EDCP) were calculated using the following formula:

EDDM/EDCP = a + bH c/(c + k_p) H EXP [- (c + k) H T]

Where, k_p is the estimated rate of out flow from the rumen and T is the time.

Statistical analysis: The data for *in situ* degradability study were analyzed for degradation characteristics using NAWAY Computer Programme. The resultant degradation characteristics were analyzed for ANOVA using Latin Square Design. The data for proximate analysis and *in vitro* digestibility were analyzed using the MSTAT statistical program using Completely Randomized design (CRD). The differences among the treatment means were determined by the least significant difference method (LSD) (Gomez and Gomez, 1984).

Results and Discussion

Nutrient composition of rice straw: Dry matter content of high fermented straw was significantly (P<0.01) lower than control and low fermented (Table 1), however, the latter two treatments had similar (P>0.05) DM contents. Among nutrients, CF and NFE were influenced significantly (P<0.05) by the level of fermentation. However, CP, EE, and ash was similar (P>0.05) irrespective of level fermentation. Significantly higher DM content of unfermented straw compared with high fermented straw indicates that, the straw when fermented, loses its dry matter because there occurs losses of nutrients from straw. Low level of fermentation does not affect its DM content considerably. The OM and CP contents of high fermented straw non-significantly decreased compared to control unfermented straw. These two nutrients were expected to be significantly lower in high fermented straw than that of control straw, but it did not happen, which might be due to the reason that the straw, although considered as high fermented, was not probably rotten enough to make significant difference in these nutrients. As has been expected, the significantly (P<0.05) lower NFE content of high fermented straw than that of unfermented control straw clearly indicates the deteriorating effect of fermentation of straw due to dampness on its quality. It is fact that NFE contains mostly soluble carbohydrates that are quite likely to be washed out by the rain water and wet condition under traditional storage system of straw. This result has been supported by Tripathi *et al*. (1995) who have reported that during the traditional system of storage of straw, loss of soluble nutrients by rain was an important factor. Fermentation of straw also damages its fibre content as can be observed from the reduced CF content of high fermented straw compared to that of control straw.

***In vitro* digestibility of rice straw:** The degree of fermentation had apparently no significant (P>0.05) effect on ME content of rice straw, although it was evident that, the ME value for control straw was slightly higher than that for fermented straw (Table 2). However, the degree of fermentation significantly (P<0.01) influenced the IVOMD of different treatments (control, low and high fermented straw). Fermentation of straw due to dampness resulted in significantly (P<0.01) decreased IVOMD of the straw compared to that of the control straw. High fermented straw gave significantly (P>0.01) lower value (40.69 g/100g) than those of low fermented (43.24 g/100 g) and unfermented control straw (44.64 g/100g).

Table 1: Effect of degree of fermentation of rice straw on its nutrient composition

Parameters	Treatments			SED	Level of significance
	Control	Low fermented	High fermented		
Dry matter (g/100 g)	92.82[a]	92.05[a]	91.22[b]	0.31	*
Chemical composition (g/100g DM)					
Organic matter	87.71	85.93	83.95	0.35	NS
Crude protein	4.12	4.06	3.92	0.11	NS
Crude fibre	33.51[a]	33.02[a]	31.07[b]	0.65	*
Ether extract	2.17	2.09	2.89	0.13	NS
Ash	12.29	14.07	16.05	0.35	NS
Nitrogen free extract	47.91[a]	46.76[b]	46.07[b]	0.67	*

Table 2: Effect of degree of fermentation on its metabolizable energy (ME) content and *In vitro* organic matter digestibility (IVOMD) of rice straw

Parameters	Treatments			SED	Level of significance
	Control	Low fermented	High fermented		
ME (MJ/kg DM)	5.48	5.32	5.15	0.12	NS
IVOMD (g/100g DM)	44.64[a]	43.24[a]	40.69[b]	0.95	**

Table 3: Degradation characteristics of dry matter of different level of fermented rice straw in the rumen of cattle

Treatments	Parameters					
	a	b	a + b	c	RSD	EDDM
Control	4.19	30.30	34.52	0.059	1.49	19.26[b]
Low fermented	4.99	25.54	30.54	0.061	1.20	17.70[ab]
High fermented	2.08	27.00	29.11	0.042	0.85	13.03[a]
SED	0.72	2.19	2.49	0.02	-	0.32
Level of significance	NS	NS	NS	NS	-	*

The values are described by the factor for the exponential equation, $P = a + b\,(1–e^{-ct})$

Table 4: Degradation characteristics of crude protein of different level of fermented rice straw in the rumen of cattle

Treatments	Parameters					
	a	b	a + b	c	RSD	EDDM
Control	1.07	29.44	30.51	0.0219	0.55	10.83[a]
Low fermented	1.82	30.27	32.12	0.0233	1.08	14.67[ab]
High fermented	2.40	29.40	41.80	0.0395	1.15	17.10[b]
SED	0.40	4.93	5.88	0.03	-	0.36
Level of significance	NS	NS	NS	NS	-	*

The values are described by the factor for the exponential equation, $P = a + b\,(1–e^{-ct})$

The values for the latter two straws did not differ significantly (P>0.05) between them. *In vitro* OM digestibility (IVOMD) of the high fermented rice straw were significantly lower than unfermented control straw, which might be due to the following reasons. The fermented straw should logically loss some nutrients, its natural constituents and to some extent chemical makes up and physical forms, and that might have adverse effects on the digestibility of straw. Mamun (2001) reported the lower IVOMD of rice straw of the traditional storage compared to improved storage. Haque and Akbar (1988) which also supports the findings present study close to those report the values for in vitro digestibility studies of control straw. The non-significant difference between low fermented and control straw indicates that fermentation of straw at low level does not have much deteriorating effect on digestibility of straw. The lack of significant difference between the high fermented and unfermented straw in respect of metabolizable energy (ME) content revealed that fermentation due to dampness did not significantly but slightly decreased ME content of straw.

Degradability of dry matter of different fermented rice straw: The degradation of DM of all straw had similar trend of steady increase with time and the total value was the lowest for high fermented straw and the highest for the unfermented straw (Fig. 1). This might have been

Table 5: Level of aflatoxin in different fermented rice straw collected from research area

Treatments	Type of aflatoxin	Aflatoxin level	Limit of detection
Control	B_1, B_2 G_1 and G_2	(–) ve	20 ppb
Low fermented	B_1, B_2 G_1 and G_2	(–) ve	20 ppb
High fermented	B_1, B_2 G_1 and G_2	(–) ve	20 ppb

Table 6: Aflatoxin M_1 level in milk samples collected from Trishal and Muktagacha area

Area	Aflatoxin M_1 (µg/kg)	Limit of detection
Muktagacha (1st collection)	Nil	0.001 µg/L
Trishal (1st collection)	0.0006	0.001 µg/L
Muktagacha (2nd collection)	Nil	0.001 µg/L
Trishal (2nd collection)	0.004	0.001 µg/L

Table 7: Aflatoxin level in milk samples collected from Bharadova and Motbari villages of Trishal Upazilla

Village	Aflatoxin M_1 (µg/kg)	Limit of detection
Bharadova 1	0.006	0.001 µg/L
Bharadova 2	0.002	0.001 µg/L
Motbari 1	Nil	0.001 µg/L
Motbari 2	0.001	0.001 µg/L

1 = Sample 1, 2 = Sample 2

the effect of fermentation of straw due to dampness. Thus it may be inferred that, there is a negative effect of fermentation of straw on its degradation of DM. The degradation of DM in the fore-stomachs of ruminants is influenced by a number of factors, some of which are related to diets, others to the animals. An important dietary factor seems to be solubility of the nutrients (Tamminga, 1979). The mean values for rapidly soluble fraction 'a', slowly degradable fraction 'b', potential degradable fraction 'a + b' and the rate of degradation of slowly degradable fraction 'c' were not significantly (P>0.05) different among the treatments (Table 3). However, the mean values for effective degradability of DM (EDDM) were significantly (P<0.05) different among the treatments. Although the differences were non-significant, unfermented control straw had the highest 'b' value (30.30%) followed by that for high fermented (27.00%) and then by that for the low fermented straw (25.54%). It is also evident that, the EDDM value for high fermented straw was significantly (P<0.01) lower than that for unfermented control straw. The considerably low value for the rapidly soluble fraction of fermented straw compared to that for control straw indicates that the dampness and wetness removes away some portion of soluble fraction of nutrients in straw which can be supported by the lower CF and NFE content of straw as has been shown in Table 1. The lower NFE value in the fermented straw was also reported by Mamun (2001). The non-significant differences among the values for 'b' and 'a + b' for all treatments suggest that the fermentation of straw has little effect on the potential

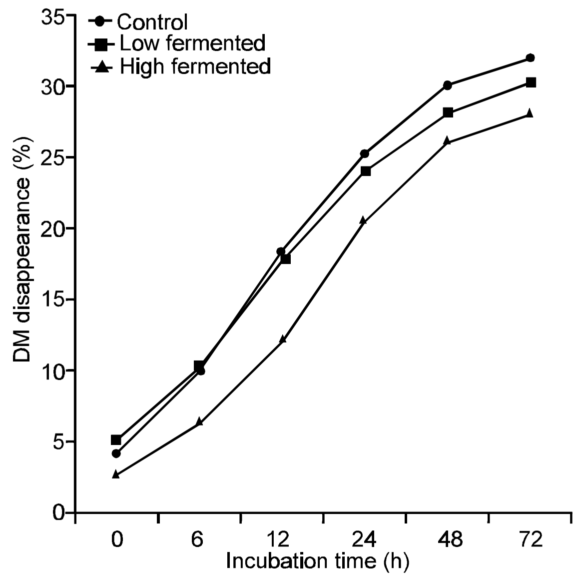

Fig. 1: Dry matter (DM) disappearance (%) from nylon bags, as a function of time when different level of fermented rice straw samples was incubated

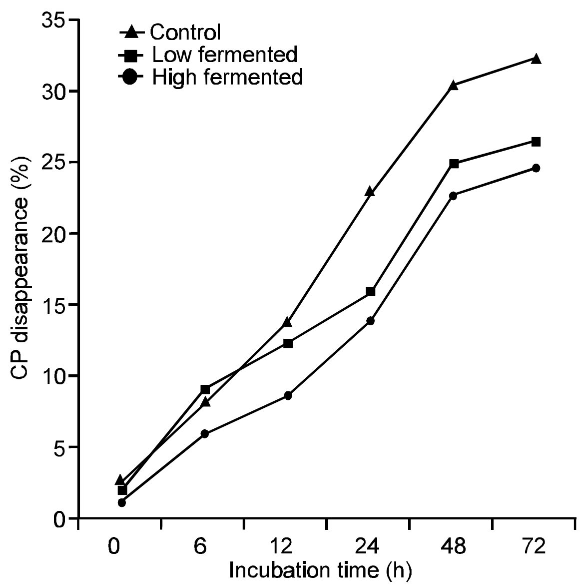

Fig. 2: Crude protein (CP) disappearance (%) from nylon bags, as a function of time when different level of fermented rice straw samples was incubated

degradation of rice straw. However, the fermentation of straw due to dampness has significant negative effect on the EDDM which is evident from the significantly (P<0.05) lower value of high fermented straw than that of control straw. This view may be supported by the significant decrease in IVOMD value of this straw than that of the control, which has been discussed earlier.

Degradability of crude protein of fermented rice straw: The degradation of CP of all straw had similar trend of steady increase with time and the total value was the lowest for unfermented straw and the highest for the high fermented straw (Fig. 2).The mean values for readily soluble fraction 'a', slowly degradable fraction 'b', potentially degradable fraction 'a + b' and the rate of degradation of slowly degradable fraction 'c' were not significantly (P>0.05) different among the treatments. On the other hand, significant (P<0.05) variation was observed among the treatments as regards to effective degradability of CP (EDCP). The values for EDCP for high fermented straw (17.10%) was significantly (P<0.05) higher than those of control (10.83%) but not than low fermented straw (9.57%). Although, there are no significant differences, rapidly soluble fraction was the highest (2.40%) in high fermented straw and the lowest in control straw (Table 4). The 'b' values were more or less similar in all treatments, however, 'a + b' value of high fermented straw was higher in high fermented straw than unfermented control straw.

Aflatoxin level in straw and milk samples: No detectable levels of aflatoxins (B_1, B_2 G_1 and G_2) were found in any of the rice straw samples (Table 5). However, trace amount of aflatoxin M_1 were detected in the milk of Trishal area but not in Muktagacha area. The level of aflatoxin M_1 found in samples of Trishal in first collection and second collection was 0.0006 µg/kg and 0.004 µg/kg, respectively (Table 6). It is clear from the table that most of the aflatoxin M_1 contamination was in the milk collected from Bharadova village. It has been expected that at least high fermented straw should contain aflatoxin. However, none of the straw samples contained detectable level of aflatoxin. It does not necessarily mean that aflatoxins are totally absent in damp straw. In this study, the limit of detection was 20 µg/kg, which is the toxic level. There might be aflatoxin in high fermented straw in the level just below 20 µg/kg, which may be increased to become detectable at toxic level if there is high degree of dampness. The lack of detectable level of aflatoxins in the high fermented straw might be due to the reason that the fermentation or fungal population and their maturity was not enough to produce considerable amount of toxin. Another reason might be that as the straw samples from two areas, Muktagacha and Trishal, were mixed together and analyzed, therefore, the possibility of the high level of mycotoxin has been reduced. If the samples of two areas could have been analyzed separately, there might have been detectable level of toxin. There was no detectable level of aflatoxin M_1 in the milk samples of Muktagacha area indicating that straw fed to cattle of this area is less fermented and more safe to feed to the cows. The reason for lack of detectable level of toxin could be that the milk samples, collected from Trishal area are mostly from the cows fed on Aus and Boro straw compared with the cows fed mostly Boro straw in Muktagacha area. It can be mentioned here that Aus straw is usually damaged more by wetness than the Boro straw. The explanation for the presence of toxin in milk, but not in straw is such that the detection level of straw analysis was 20 µg/kg, but that of milk was 0.001µg/L. That means the detection level of milk was much lower than that of straw. If the straw could have been analyzed with the low level as in the case of milk, there would have been toxin detected in straw. There is evidence that the mycotoxin present in animal feed might be transmitted to cows milk and through milk it might be transmitted to human being consuming milk (Coker, 1999). When milk from the two villages of Trishal area were separately analyzed, it was found that the most of the detected aflatoxin M_1 was present in milk of Bharadova village (Table 7), and a very small level of Motbari (Table 7). This could be because, practically, Bharadova is a low lying area compared to Motbari and more Aus straw is cultivated there and more dampness of straw was observed in Bharadova than Motbari.

References

AOAC., 1990. Association of Official Analytical Chemists. Official Methods of Analysis. 15th Ed. McGraw Hill, New York, Washington DC.

BBS., 1999. Bangladesh Bureau of Statistics, Year Book of Agricultural Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Bradburn, N., R. D. Coker and K. Jewers, 1990. A comparative study of phenyl bonded phase, CB and Romer clean-up procedures for determining aflatoxin levels in maize by bi-directional HPTLC. Chromatographia, 29: 177-181.

Coker, R. D., 1979. Aflatoxin: past, present and future. Trop. Sci., 21: 143-162.

Coker, R. D., 1999. Mycotoxins: The silent threat to human and animal health. Inaugural lecture series, The University of Greenwich, UK.

Gomez, K. A. and A. A. Gomez, 1984. Statistical procedures for Agricultural Research. 2nd edition, New York, USA.

Haque, K. S. and M. A. Akbar, 1988. Effect of supplementation of *Leucaena leucocephala* leaf meal to rice straw treated with poultry excreta or urea on its digestibility *in vitro*. Bangladesh Vet. J., 20: 65-71. Ind. J. Anim. Nutr., 9: 197.

Jones, B. D. and R. D. Coker, 1994. The effect of mycotoxins in animals with particular reference to the "carry-over" of mycotoxins from naturally contaminated feed to food products. A review submitted to MAFF under contract.

Mamun, M. A., 2001. Current practice and improved storage of rice straw and their impact on straw quality, safety and level of mycotoxin contamination. M. S. thesis. Department of Animal Nutrition, Bangladesh Agricultural University, Mymensingh.

Mehrez, A. Z. and E. R. Orskov, 1977. A study of the artificial fibre bag technique for determining the digestibility of feeds in the rumen. J. Agri. Sci. (Camb.), 88: 546-660.

Menke, K. H. and H. Steingass, 1988. Estimation of the energetic feed value obtained from chemical analysis and *in vitro* gas production using rumen fluid. Anim. Res. Dev., 28: 7-56.

Orskov, E. R. and J. McDonald, 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. J. Agri. Sci. (Camb.), 90: 499-503.

Tamminga, S., 1979. Protein degradation in the forestomach of ruminants. J. Anim. Sci., 49: 1615.

Tripathi, H. P., A. P. Singh, V. S. Upadhyay, H. P. Kessels, A. S. Harika, S. Sahab and M. N. M. Ibrahim, 1995. Forage conservation, storage and feeding. In: Handbook for straw feeding systems. Singh, K. and Schiere, J. B. (eds). Indo-Dutch project on bioconversion of crop residues (publishers). pp: 303-323.