

# METHODS TO IMPROVE UTILIZATION OF RICE STRAW

## I. EFFECTS OF MOISTENING, SODIUM CHLORIDE AND CHOPPING ON INTAKE AND DIGESTIBILITY

A. L. Badurdeen, M. N. M. Ibrahim<sup>1</sup> and J. B. Schiere<sup>2</sup>

Department of Animal Science  
University of Peradeniya, Peradeniya, Sri Lanka

### Summary

Two studies were conducted using 40 cross-bred bulls to study the effect of chopping, moistening with water or common salt solution on the nutritive value of rice straw (variety BG-400). Moistening with water did not significantly effect digestibility or intake of rice straw. As compared to straw fed in the long form, chopping did not significantly influence intake (2.33 vs 1.97 kg 100 kg BW<sup>-1</sup> day<sup>-1</sup>, respectively), but significantly ( $p < 0.05$ ) decreased the digestibility (41.6 vs 37.4%) and intake of digestible dry matter (0.99 vs 0.74 kg 100 kg BW<sup>-1</sup> day<sup>-1</sup>). Rice straw moistened with 2 or 4% common sea salt solution and directly fed to animals (Expt. 1) did not significantly effect its digestibility (43.9 and 43.1%, respectively) or intake (2.66 or 2.59 kg 100 kg BW<sup>-1</sup> day<sup>-1</sup>, respectively), but over night storing of 2% salt solution sprayed straw (Expt. 2) significantly reduced its digestibility (33.6%). The latter is difficult to explain because the sodium concentration (mg/g straw dry matter) was lower than 4% salt solution treatment used in experiment 1 (3.30 vs 5.22). It is concluded that chopping, moistening with water or NaCl salt solution did not significantly improve the nutritive value of rice straw.

(Key Words: Rice Straw, Bull Calves, Chopping, Moistening, Sodium Chloride)

### Introduction

Chopping of rice straw is often considered a process by which the utilization of straw by the animal could be enhanced, because it reduces wastage and avoids selective consumption. In terms of animal response the length to which straw is chopped is critical, and the effect of chopping (in terms of increased dry matter intake) is much smaller as compared to grinding and pelleting if it is not accompanied by a great reduction in particle size (Honing, 1975). If chopping gives a positive response in intake and digestibility, this process may be suitable for application by small dairy farmers. However, studies conducted in Indonesia (Winugroho et al., 1983), Malaysia (Devendra, 1983), the Phil-

ippines (Castillo et al., 1982) and Sri Lanka (Schiere and Ibrahim, 1989) have revealed variable results.

As the water soluble content in a feed makes the initial contribution to its digestibility, it is important to make clear distinction between wetting/moistening and soaking. When referring to wetting or moistening it is customary to use a water to straw ratio of 1:1, while soaking involves much larger volumes of water. Dumlao and Perez (1976) reported dry matter losses of 8-14% when rice straw was soaked for 3 days indicating removal of cell contents and reduced feeding value. As with chopping, the beneficial effects of moistening or wetting has not yet been clearly demonstrated. Clear conclusions cannot be drawn from the limited information available from literature (Talapatra et al., 1949; Castillo et al., 1982; Devendra, 1983).

Most of the earlier experiments with NaCl were designed to study the physiological aspect of the animal as regard to Na and Cl (Underwood, 1981), but little or no information is available on the effect of supplementary salt on voluntary feed intake and digestibility of roughages. Wanapat et al. (1986) treated rice straw

<sup>1</sup>Address reprint requests to Dr. M. N. M. Ibrahim, Department of Tropical Animal Production, Agricultural University, P. O. Box 338, 6700 AH Wageningen, The Netherlands.

<sup>2</sup>Department of Tropical Animal Production, Agricultural University, P.O. Box 338, 6700 AH Wageningen, The Netherlands.

Received July 26, 1993

Accepted November 15, 1993

with urea and sodium chloride (NaCl) solution, and reported that NaCl had no effect on intake, but in some cases it reduced digestibility. No other data is available to confirm their findings. Rice straw contains about 0.5 g of Na/kg feed (dry matter), while animals requirement is 1.4 g/kg feed (Ranawana, 1985) for rumen fermentation or body metabolism. The potassium (K) content of rice straw is more than the animals requirement (12 vs 4 g/kg), and most K is present in the form of potassium oxalate. Castillo et al. (1982) reported that soaking of chopped straw in water did not increase the dry matter intake, but it reduced the oxalate content of straw.

In order to study the effect of these different treatments, two studies were conducted to:

- compare the effect of spraying with water or salt solution on intake and digestibility of rice straw
- compare the intake and digestibility of chopped and unchopped rice straw

## Materials and Methods

### Treatments and experimental diets

**Experiment 1: Effect of spraying water and different levels of NaCl salt solution on intake and digestibility of rice straw**

Four diets were tested:

- Untreated rice straw (US)
- Rice straw sprayed with water only (WS)
- Rice straw sprayed with 2% salt solution (WS2)
- Rice straw sprayed with 4% salt solution (WS4)

The straw (variety BG-400) used in the study was collected from the dry zone Rice Seed Production Farm, Sri Lanka. Salt solutions (2 and 4%) were prepared by dissolving 2 and 4 kg of common salt (sea salt) in 100 litres of water. The diets (WS2 and WS4) were prepared by spraying the salt solution onto air dry straw (100 litres per 100 kg air dry straw) and thoroughly mixing it. Similarly, the diet WS was prepared by spraying water onto straw (100 litres per 100 kg straw). The diets were prepared in the morning, stored in large polythene bags and fed to animals during the same day at three hour intervals.

**Experiment 2: Effect of chopping, spraying water and 2% NaCl salt solution on intake and digestibility of rice straw**

Four diets were tested:

- Rice straw fed in the long form (LS)
- Chopped rice straw (CS)
- Rice straw (unchopped) sprayed with water (LWS)
- Rice straw (unchopped) sprayed with 2% salt solution and stored over night before feeding (LWS2)

The straw used in this study was of the same variety as that used in experiment 1. The salt solution (2%) was prepared by dissolving 2 kg of common salt (sea salt) in 100 litres of water. The water or salt solution was sprayed on to air dry straw (100 litres per 100 kg straw) and thoroughly mixed. The diets LWS and LWS2 were prepared in the evening, stored in large polythene bags and fed to animals the next day at three hour intervals. The difference with experiment 1 is that this straw was kept overnight before feeding.

### Animals and experimental design

In both experiments, forty cross-bred (Sahiwal  $\times$  indigenous) bull calves weighing  $160 \pm 20$  kg liveweight were divided into ten groups of 4 animals on the basis of their body weight. Within each group the animals were randomly allotted to the 4 diets, thus forming a randomized complete block design (RCBD). The animals were tethered in a well ventilated shed which was equipped with individual feeding troughs. Clean drinking water was available at all times.

### Measurement and laboratory analyses

Both experiments lasted 45 days with an adaptation period of 2 weeks, a pre-experimental period of one week and a collection period of 24 days. The animals were fed at 3 hourly intervals throughout day and night. During the collection period the dry matter intake (DMI) of each animal was determined by measuring the amount of straw offered and refused each day. The dry matter content (DM) of straw offered and refused was determined by drying in a forced

# METHODS TO IMPROVE UTILIZATION OF RICE STRAW

draft oven at 100°C for 24 hours. Sub samples of the feed offered and grab samples of faeces from the rectum were collected daily and stored at -4°C. At the end of the collection period the samples were thawed, bulked, thoroughly mixed and representative sub samples were dried at 70°C for 48 hours. The dried samples were ground to pass through a 1 mm sieve and analyzed for dry matter and organic matter (AOAC, 1981), and for acid insoluble ash (AIA) by the method described by Van Keulen and Young (1977), representing an indicator method to determine digestibility. Feed samples were also analyzed for nitrogen (AOAC, 1981) and for sodium and potassium by flame photometer.

## Statistical analysis

The data were subjected to the standard analyses of variance procedure (Snedecor and Cochran, 1989).

## Results

TABLE 1. EFFECT OF WETTING WITH WATER OR SALT SOLUTION ON CHEMICAL COMPOSITION (DRY MATTER BASIS), DIGESTIBILITY AND INTAKE OF RICE STRAW (EXPERIMENT 1). DIGESTIBILITY AND INTAKE VALUES ARE MEAN OF 10 ANIMALS

	Untreated straw	Water sprayed straw	NaCl sprayed straw 2%	4%
Chemical composition:				
Dry matter (%)	88.3	48.0	48.8	48.7
Ash (%)	16.9	17.6	17.2	19.0
Acid insoluble ash (%)	14.4	14.2	14.5	14.2
Crude protein (%)	5.1	5.1	5.1	4.9
Sodium (mg/g)	0.45	0.62	2.59	5.22
Potassium (mg/g)	8.96	9.02	11.05	14.13
Digestibility (%):				
Dry matter	42.7 (1.17)	43.1 (0.35)	43.9 (0.45)	43.1 (0.61)
Organic matter	47.3 (1.56)	49.6 (0.47)	51.0 (0.44)	48.4 (0.78)
Intake (kg 100 kg BW <sup>-1</sup> day <sup>-1</sup> ):				
Dry matter	2.54 (0.08)	2.63 (0.15)	2.66 (0.21)	2.59 (0.05)
Organic matter	2.11 (0.13)	2.18 (0.23)	2.15 (0.22)	2.13 (0.09)

Figures in parentheses are  $\pm$  standard errors.

## Experiment 1

The chemical composition of the diets used, mean intake and digestibility of these diets is given in table 1. Except for ash, Na and K the other nutritive value parameters remained unchanged. Spraying with water increased the Na content by 0.17 mg/g straw, and spraying with 2 and 4% salt solution further increased the concentration by 1.69 and 2.62 mg/g straw, respectively. The corresponding increase in K concentration in the 2 and 4% salt solution sprayed diets was 2.03 and 5.11 mg/g straw, respectively.

Both the digestibility and intake values obtained for the diets tested was statistically non-significant. DMI's were within the range of 2.54 and 2.66 kg 100 kg BW<sup>-1</sup> day<sup>-1</sup> for the diets tested, while the dry matter digestibility (DMD) values varied between 42.7 and 43.9%. The organic matter intakes (OMI) and organic matter digestibilities (OMD) of the diets ranged from 2.11 to 2.18 kg 100 kg BW<sup>-1</sup> day<sup>-1</sup> and 47.3 to 51.0%, respectively.

**Experiment 2**

The chemical composition, mean intake and digestibility of the diets is given in table 2. As compared to straw sprayed with water, spraying with salt solution increased the Na and K contents in straw by 2.86 and 2.34 mg, respectively.

The DMI values of 2.33 and 1.97 kg 100 kg BW<sup>-1</sup> day<sup>-1</sup> obtained for unchopped and chopped straw, respectively, were not significantly different. However, the digestibility of the chopped straw diet was significantly lower than of the unchopped straw (37.4 vs. 41.6%). Consequently, the diges-

tible DMI was significantly ( $p < 0.05$ ) lower in chopped than in unchopped straw.

Similarly, as in experiment 1, spraying rice straw with water or 2% salt solution did not significantly affect the DMI. But, the digestibility of straw sprayed with 2% salt solution was significantly ( $p < 0.05$ ) lower (33.6%) than unchopped and straw sprayed with water (41.6 and 40.7%, respectively), resulting in decreased intake of digestible dry matter following the same pattern as that of digestibility.

TABLE 2. EFFECT OF CHOPPING, SPRAYING WITH WATER OR SALT SOLUTION ON THE CHEMICAL COMPOSITION (DRY MATTER BASIS), DRY MATTER INTAKE (DMI), DRY MATTER DIGESTIBILITY (DMD) AND DIGESTIBLE DRY MATTER INTAKE (DDMI) OF RICE STRAW (EXPERIMENT 2). DIGESTIBILITY AND INTAKE VALUES ARE MEAN OF 10 ANIMALS

	Untreated straw	Chopped straw	Water sprayed	NaCl sprayed straw
Chemical composition :				
Dry matter (%)	92.0	92.1	42.4	50.0
Ash (%)	17.4	18.2	17.9	17.0
Acid insoluble ash (%)	14.0	13.7	14.2	14.0
Crude protein (%)	4.9	5.1	5.0	5.2
Sodium (mg/g)	0.46	0.47	0.44	3.30
Potassium (mg/g)	10.31	10.53	11.44	13.78
DMD %	41.6 <sup>a</sup> (1.20)	37.4 <sup>bc</sup> (2.13)	40.7 <sup>ab</sup> (2.13)	33.6 <sup>c</sup> (0.94)
Intakes :				
DMI (kg 100 kg BW <sup>-1</sup> day <sup>-1</sup> ) :	2.33 (0.11)	1.97 (0.17)	2.20 (0.17)	1.94 (0.23)
DDMI (kg 100 kg BW <sup>-1</sup> day <sup>-1</sup> )	0.99 <sup>a</sup> (0.06)	0.74 <sup>b</sup> (0.07)	0.89 <sup>a</sup> (0.04)	0.65 <sup>b</sup> (0.09)

Figures in parentheses are  $\pm$  standard errors

Within rows means with dissimilar superscripts are significantly different ( $p < 0.05$ ).

**Discussion**

Nutritive value parameters such as crude protein and acid insoluble ash contents were not affected by chopping, spraying with water or salt solution. In both experiments reported in this study, spraying or wetting with water showed no significant effect on intake and digestibility. In experiment 1 the digestibility and intake of the water sprayed straw was marginally higher than the untreated straw (see table 1) and the

reverse was true in experiment 2 (see table 2).

In a similar experiment, when wheat straw was sprayed with water and offered to calves with a fixed amount of concentrates, the total feed intake increased (Chaturvedi et al., 1973), but there was no effect of wetting on organic matter digestibility. In contrast, Devendra (1983) reported that sheep consumed and digested less organic matter from wetted straw than from dry straw. Talapatra et al. (1949) studied the effect of soaking, washing or ensiling rice straw with water.

They reported that soaking in water not only removed potassium oxalate, but it also reduced dustiness and it increased the palatability of straw. Castillo et al. (1982) found that soaking chopped straw for 2 h in a drum followed by 3 h drainage did not improve intake by buffaloes offered rice straw *ad libitum* and a concentrate mix. They also found that the soluble oxalate content in water soaked straw was 78% less as compared to unsoaked straw (0.24% vs 1.08%).

Chopping of rice straw did not increase the DMI, but in contrast it significantly ( $p < 0.05$ ) decreased the digestibility and intake of digestible dry matter (see table 2). Castillo et al. (1982) found that buffaloes fed concentrates at 0.5% liveweight consumed slightly more chopped than long rice straw (67 vs 63 g/kg  $W^{0.75}$ ), while Devendra (1983) found no difference between long and chopped straw in dry matter intake (51 vs 50 g/kg  $W^{0.75}$ ) and digestibility (46 vs 41%) by sheep. Winugroho et al. (1983) also found that chopping of rice straw less than 4 cm pieces resulted in lower DMI. With other cereal straws, weight gains of animals fed long and chopped straw-based diets have been found to be similar (Doyle et al., 1986), indicating that chopping is unlikely to affect the feeding value of rice straw. As in the case with grinding, positive effects due to chopping could only be achieved if it results in increased intakes. Even though increased intake would result in lower digestibility, the net effect in terms of intake of digestible dry matter would be higher.

Theoretically, 2% NaCl solution (20 mg/g straw) should have increased the Na content by 7.86 mg/g straw, but the actual increase was only 1.69 mg (see table 1). Also, spraying with 2% NaCl solution increased the K content by 2.03 mg/g straw. This indicates that the common sea salt used in the experiment contained considerable amount of K, mostly likely as KCl.

In experiment 1, the moistening of rice straw with 2 or 4% salt solution did not significantly effect dry matter intake or its digestibility, but overnight storing of 2% salt solution sprayed straw significantly reduced its digestibility (see table 2). The Na content in straw sprayed with 2% salt solution and kept over night was much lower as compared to 4% salt solution sprayed diet (3.30 vs 5.22 mg/g), but the significantly lower digestibility value obtained for the former

is difficult to explain. Similar negative response to addition of salt was reported by Wanapat (1986), where rice straw was treated with 5% urea with or without NaCl salt solution and fed to cattle. He found that there was no significant effect on intake due to addition of salt (2.6 vs 2.5 kg % BW), but the organic matter digestibility of the salt added diet was significantly ( $p < 0.05$ ) lower (64 vs 57%). Spraying of 2 and 4% salt solution increased the Na content of rice straw above the animals's requirement of 1.49 mg/g feed. If the low Na content rice straw is a factor that reduces the intake, upgrading by this way should increase the intake. However, the result of our study and that of Wanapat (1986) failed to show any positive responses. There is evidence in literature to show that addition of electrolytes like NaCl and KCl to the rumen acutely decreases saliva production (Wilson, 1963), at higher doses also feed intake (Wilson, 1966).

Spraying of rice straw with water or salt solution also increased the K content. Castillo et al. (1982) reported a decrease in K content when he soaked the straw in water. In our study the increase in K content may be due to K in water and common salt. In order to get reliable information on K content and its availability, water and NaCl free from K salts should be used.

## Conclusion

Feeding of water or salt solution sprayed straw directly or after storing over night did not yield any beneficial results in Sri Lanka or Thailand or in the Philippines. However, in parts of India it is traditional to soak straw prior to feeding and this is believed to have beneficial effects through removal of oxalates. Similarly, chopping of rice straw has also shown varying results in different countries. Whether these variations are due to straw quality, chopping length or type of animal used is yet to be demonstrated and systematic study seems warranted.

## Acknowledgements

The authors wish to thank the Sri Lankan and the Netherlands authorities who supported the Straw Utilization Project (SUP), Ms. Chandra

Unawatune and Mr. H. G. D. Perera for assisting with the laboratory analyses. Mr. A. L. Badurdeen was a recipient of M. Phil. fellowship funded by the SUP Sri Lanka.

### Literature Cited

- AOAC. 1981. Official Methods of Analysis 13<sup>th</sup> Edn. Association of Official Analytical Chemists, Washington, D.C.
- Castillo, L. S., D. H. Roxas, M. A. Chavez, V. G. Memongan and S. K. Ranjhan. 1982. The effects of a concentrate supplement and of chopping and soaking rice straw on its voluntary intake of carabaos. In: The Utilization of Fibrous Agricultural Residues as Animal Feeds. (Ed. Doyle, P. T.), pp. 74-80. School of Agriculture and Forestry, University of Melbourne, Victoria, Australia.
- Chaturvedi, M. L., U. B. Singh and S. K. Ranjhan. 1973. Effect of feeding water soaked and dry wheat straw on feed intake, digestibility of nutrients and VFA production in growing zebu and buffalo calves. Journal of Agricultural Science, Cambridge 80:393-397.
- Devendra, C. 1983. Physical treatment of rice straw for goats and sheep and the response to substitution with variable levels of cassava (*Manihot esculenta* Crantz), leucaena (*Leucaena Leucocephala*) and gericidia (*Gericidia Maculata*) forages. MARDI Research Bulletin 11, 3:272-290.
- Doyle, P. T., C. Devendra and G. R. Pearce. 1986. Rice Straw as Feed for Ruminants. International Development Program of Australian Universities and Colleges Limited (IDP), Canberra, Australia.
- Dumlao, C. T. and C. B. Perez. 1976. Improving the feeding value of rice straw by calcium oxide treatment. Philippines Journal of Veterinary and Animal Science 2:95-110.
- Honing, Y. van der. 1975. Intake and utilization of energy of rations with pelleted forages by dairy cows. Agricultural Research Reports 836. Centre for Agricultural Publishing and Documentation, Wageningen, the Netherlands.
- Ranawana, S. E. E. 1985. Supplementation of straw based ration with minerals. In: Potential of Rice Straw in Ruminant Feeding - Research and Field Application. (Eds. Ibrahim, M. N. M., Schiere, J. B. and Siriwardena, J. A. de S.), pp. 118-137. Straw Utilization Project Publication No. 2. Sri Lanka.
- Schiere, J. B. and M. N. M. Ibrahim. 1989. Feeding of Urea-Ammonia Treated Rice Straw. A Compilation of Miscellaneous Reports Produced by the Straw Utilization Project. Pudoc, Wageningen, The Netherlands.
- Snedecor, G. W. and W. G. Cochran. 1989. Statistical Methods. 8th edn. Iowa State University Press, Ames, Iowa, USA.
- Talapatra, S. K. 1949. Calcium assimilation in ruminants on oxalate rich diets. Journal of Agriculture Science 38:163-173.
- Underwood, E. J. 1981. The mineral nutrition of livestock. Commonwealth Agricultural Bureau, London.
- Van Keulen, J. and B. A. Young. 1977. Evaluation of acid insoluble ash as a natural marker in ruminant digestibility studies. Journal of Animal Science 44:282-286.
- Wanapat, M. 1986. Development of straw utilization as ruminant feed in Thailand. In: Rice Straw and Related Feed in Ruminant Rations. (Eds. Ibrahim, M. N. M. and Schiere, J. B.), pp. 86-98. Straw Utilization Project Publication No. 2. Kandy, Sri Lanka.
- Winugroho, M., B. Bakrie, T. Panggabean and N. G. Yates. 1983. Effect of particle size and alkali treatment on intake and digestibility of organic matter of rice straw fed to cattle. In: The Utilization of Fibrous Agricultural Residues as Animal Feed (Ed. Doyle, P. T.), pp. 176-181. University of Melbourne, Victoria, Australia.
- Wilson, A. D. 1963. The effect of diet on the secretion of parotid saliva by sheep. II. Variations in the rate of saliva secretion. Australian Journal of Agricultural Research, 14:680-689.
- Wilson, A. D. 1966. The tolerance of sheep to sodium chloride in food or drinking water. Australian Journal of Agricultural Research, 17:503-514.