

Effect of naturally fermented rice straw based diet on the performance of buffalo calves

M WADHWA¹, K KAUR² and M P S BAKSHI³

Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana 141 004 India

Received: 10 June 2009; Accepted: 26 October 2009

ABSTRACT

The effects of fermented (FRS) and unfermented rice straw (RS) based complete diets on the nutrient utilization and growth performance of 8 male Murrah buffalo calves (114±9 kg BW) was assessed. The animals divided in to 2 equal groups were offered isonitrogenous and isocaloric diet containing either RS supplemented with high protein (CP 21%) concentrate mixture or FRS with low protein (CP 17%) concentrate mixture in 60:40 ratio for 270 days. The DM intake was comparable in both the groups. The digestibility of nutrients especially that of cellulose and hemicellulose improved significantly, but that of CP depressed significantly in calves fed FRS than RS based diet. The significantly low ammoniacal-N in the FRS based diet was partially responsible for considerably higher TCA-N in the rumen liquor. Bacterial and protozoal populations in the rumen of animals fed FRS was higher than those fed RS base diet. The endodinomorphs were more in number compared to holotrichs, in general as well as in FRS fed groups. The N-intake was comparable in both the groups, however, the faecal-N excretion was significantly higher in FRS than RS supplemented group. Reverse but statistically non significant trend was observed in urinary-N excretion, which resulted in higher efficiency of utilization of absorbed-N in FRS than RS fed group. The ME content of the diet containing FRS improved significantly. The favorable microbial population in the rumen, higher digestibility and efficient utilization of nutrients were responsible for considerably higher daily live weight gain in calves fed with FRS than that with RS based diet. It was concluded that naturally fermented of RS with urea could be efficiently utilized in improving performance of calves, besides sparing about 70% of oilseed cake.

Key words: Fermented rice straw, Growth, Nutrient utilization, Rumen microorganisms, Straw

Wheat straw is the basal roughage in the traditional feeding system in the Northern region of India especially Punjab, Haryana and Uttar Pradesh. Therefore, most of the rice straw produced in these states (24.5 mt/annum; Anonymous 2007) is surplus and more than 80% is burnt, causing environmental pollution. The remaining rice straw is used either for card board/paper industry, as packing/bedding material, mushroom cultivation or for feeding to livestock by land-less/marginal farmers. Earlier studies revealed that rice straw could be fermented with urea in stacks and bales successfully and fermented rice straw had higher degradability than unfermented rice straw (Kaur *et al.* 2007 2008). In the present study an attempt was made to ferment rice straw with urea and to assess its impact on the performance of buffalo calves.

Present address: ¹Senior Biochemist; ²Research Associate; ³Senior Nutritionist cum Head (e-mail: bakshimps@yahoo.com), Department of Animal Nutrition.

MATERIALS AND METHODS

Fermentation of rice straw: Naturally fermented rice straw was prepared by sprinkling urea solution (14.0 kg urea in 200 litre water) on 386 kg dried chaffed rice straw (2.5–3.5 cm) and stacked for 9 days. The ratio of urea to rice straw was kept 3.5: 96.5 and moisture was 40% (Bakshi *et al.* 1987, Bakshi and Wadhwa 2001). About 50q dried, chaffed rice straw was treated and stacked.

Table 1. Ingredients composition of concentrate mixtures

Constituent	Conc-1 (HP)	Conc-2 (LP)
Maize	30	35
Mustard cake	10	10
Deoiled mustard cake	20	05
Rice bran	15	15
Deoiled rice bran	22	32
Mineral mixture	02	02
Common salt	01	01

HP, High protein; LP, low protein.

Feeding schedule: A 270-day growth trial was conducted on 8 male Murrah buffalo calves (114 ± 8.9 kg BW). The animals divided into 2 equal groups were offered either 3.00 kg untreated rice straw supplemented with 1.45 ± 0.21 kg high protein concentrate mixture with 2 kg green fodder (Table 1) or 3.00 kg naturally fermented straw (FRS) was supplemented with 1.55 ± 0.09 kg low protein concentrate mixture with 2 kg green fodder, depending upon the nutrient requirements of calves (NRC 2001). The animals were offered respective diet individually as total mixed ration (TMR). The roughage to concentrate ratio in the TMR was maintained at 60:40 in both the groups. The animals were weighed every fortnight for 3 consecutive days and the feeding schedule was adjusted accordingly. A 7-day metabolism trial was conducted at the termination of the growth study to assess nutrient utilization in the two groups.

Rumen studies: For conducting rumen studies, 3 rumen fistulated male buffaloes (464.7 ± 5.1 kg body weight) were offered either 6–7 kg untreated rice straw supplemented with 2.5 kg high protein concentrate mixture and 2 kg fresh available green fodder or 6–7 kg naturally fermented rice straw supplemented with 2.5 kg low protein concentrate mixture and 2 kg available green fodder (to meet vitamin A requirement) as TMR. The animals were adapted on the respective diet for 30 days. Thereafter, the samples of rumen contents were collected from each animal for 3 consecutive days at 0, 2, 4, 6, 8 and 10 h after feeding. The samples were filtered through 4-layered muslin cloth and preserved with few drops of mercuric chloride.

Analytical methods: Samples of feed, orts and faeces were pooled for each animal separately and thoroughly mixed. These were then ground (1 mm) and analyzed in duplicate for nitrogen and total ash (AOAC 1995), cellulose (Crampton and Maynard, 1938) and other cell wall constituents (Robertson and Van Soest 1981). The urine samples were analyzed for nitrogen content only. The ME was determined from the apparent digestible OM using the relationship given by Broster and Oldham (1981). The SRL samples were analyzed for total-N, ammoniacal-N (AOAC 1995), trichloroacetic acid precipitable-N (Cline *et al.* 1958) and

total volatile fatty acids (Barnett and Reid 1957). The data were analyzed by using completely randomized design (Snedecor and Cochran 1994).

RESULTS AND DISCUSSION

In the low protein concentrate mixture only 25% of deoiled mustard cake was used as compared to that used in high protein concentrate mixture (Table 1). The proximate and cell wall constituents of both concentrate mixtures were similar, except their CP (20.9 vs. 17.0% in HP vs LP) content (Table 2). The fermented rice straw was enriched with microbial protein, as during natural fermentation of straw with urea, there was significantly higher microbial population (bacteria, fungi and antinomycetes) in the stacks (Bakshi *et al.* 1986, Gupta *et al.* 1987, Makhdoomi *et al.* 1996), resulting in increased CP (9.9 vs. 4.8%). The hemicellulose in FRS reduced ($P < 0.05$), because microbes proliferating in the stack utilized part of it, resulting in low NDF content. The NDF content is negatively correlated to DM intake and digestibility of cell wall constituents.

The DM intake was higher in FRS than RS fed group, but the differences were statistically nonsignificant (Table 3). The digestibility of nutrients especially of cellulose and hemicellulose improved significantly ($P < 0.05$), because of the breakdown of the ligno-cellulose bond in RS by ammonia released from urea, resulting in availability of free cellulose and hemicellulose for degradation in the rumen. As observed in ammoniated wheat straw (Horten *et al.* 1982), the digestibility of CP depressed significantly ($P < 0.05$) in FRS than RS fed group, due to poor digestion and absorption of microbial cell wall-N and endogenous protein (Dias-Da-Silva and Sundstol 1986).

The effect of feeding FRS on the rumen environment in buffaloes revealed that total-N and NPN content in the strained rumen liquor were statistically comparable in both the groups (Table 4). The significantly low ($P < 0.05$) ammoniacal-N in the FRS based diet was partially responsible for considerably higher TCA-N in the rumen liquor.

The microbial (protozoa and bacteria) populations in the

Table 2. Chemical composition of feedstuffs offered to buffalo calves

Constituent	Concentrate		Rice straw		Green fodder
	HP	LP	Untreated	Urea treated	
Total ash	9.3	8.0	13.2	15.3	8.2
Organic matter	90.7	92.0	86.8	84.7	91.8
Crude protein	20.9	17.0	4.8	9.9	7.7
Neutral detergent fibre	44.5	46.0	74.0	70.0	71.0
Acid detergent fibre	17.5	17.0	48.5	56.0	42.0
Hemicellulose	27.0	29.0	25.5	14.0	29.0
Cellulose	9.0	8.5	36.0	37.0	33.0

HP, High protein; LP, low protein.

Table 3. Effect of naturally fermented rice straw on digestibility of nutrients in buffalo calves

Parameter	RS	FRS	Pooled SE
Dry matter intake, kg/d	3.7	4.5	0.40
<i>Digestibility of nutrients, %</i>			
Dry matter	42.4	47.5	4.54
Organic matter	47.2	54.0	4.27
Crude protein	67.8 ^b	45.0 ^a	1.54
Neutral detergent fiber	33.1	47.4	5.28
Hemicellulose	44.9 ^a	73.3 ^b	5.29
Cellulose	40.1 ^a	59.8 ^b	4.77

RS, Untreated rice straw; FRS, fermented rice straw; figures with different superscripts in a row differ significantly, $P < 0.05$.

Table 4. Impact of naturally fermented rice straw on the biochemical changes in the rumen, mg %

Parameter	RS	FRS	Pooled SE
Total-N	90.0	116.7	9.43
NPN	30.7	29.3	2.85
TCA-N	59.7	85.7	7.61
Ammoniacal-N	13.0 ^a	6.3 ^b	1.49
TVFA	8.4	8.8	0.18

RS, Untreated rice straw; FRS, fermented rice straw; NPN, non-nitrogen protein nitrogen; TVFA- total volatile fatty acids; TCA-N- trichloro acetic acid precipitable nitrogen; figures with different superscripts in a row differ significantly, $P < 0.05$.

rumen of animal fed FRS was higher than that in the rumen of animals fed RS. Their number increased 4 h after feeding in the rumen of animals fed either FRS/RS, though the increase was more pronounced in the rumen of animals fed FRS (Table 5). The entodionomorphs were more in number as compared to holotrichs, in general as well as in FRS fed group of animals. Amongst entodionomorphs; *E. longinucleatum*, *E. bursa*, and *E. caudatum* predominated. *Entodionomorphs* ingest plant material to degrade cellulose; this observation clearly justified their higher number in rumen of animals fed FRS resulting in higher cellulose digestibility. *Epidinium* spp. are one of the most important protozoa, which

Table 5. Impact of naturally fermented rice straw on the microbial changes in the rumen

Time, HAF	RS	FRS
	Protozoa, $\times 10^4/\text{ml}$	
0	1.98	3.05
4	3.90	5.12
	Bacteria, $\times 10^9/\text{ml}$	
0	3.32	8.06
4	4.39	10.6

HAF, Hours after feeding; RS, untreated rice straw; FRS, fermented rice straw.

Table 6. Effect of naturally fermented rice straw on N-utilization (g/d) in buffalo calves

Parameter	RS	FRS	Pooled SE
N-intake	65.4	86.2	7.40
Faecal-N	20.9 ^a	47.4 ^b	2.80
N-digested	44.5	38.9	4.97
Urinary-N	18.1	11.6	2.46
N-Retained	26.5	27.3	3.38

attach fibrous feed and invades and breaks the plant tissue to smaller pieces. The cellulase enzyme of *Epidinium* are usually endo-gluconase type, but they have to depend upon other *entodionomorphs* for complete hydrolysis. The higher number of *Epidinium*, *Polyplastron*, *Ophryoscolex* and *Ostracodinium* spp. in the rumen of animals fed FRS, were responsible for higher digestibility of hemicellulose.

Feeding FRS did effect N-intake significantly, however, the faecal-N excretion was higher ($P < 0.05$) in FRS than in RS supplemented group (Table 6) because of low CP digestibility in FRS than in RS fed group. Reverse but statistically non significant trend was observed in urinary-N excretion, which resulted in higher efficiency of utilization of absorbed-N in FRS than in RS fed group. Animals in both the groups were in positive-N balance and the differences were statistically non-significant.

The lower digestibility of CP on FRS resulted in significantly ($P < 0.05$) lower DCP content of the diet (Fig 1) than that of the RS based diet. The ME content of the diet containing FRS improved ($P < 0.05$) because of the higher digestibility of free cellulose and hemicellulose. The calves fed FRS had considerably higher live weight gain than those fed on RS based diet (Table 7), mainly due to favorable microbial population in the rumen, higher digestibility and efficient utilization of nutrients, confirming to the earlier report on naturally fermented wheat straw (Bakshi and Langar 1990, 1994). It was concluded that natural fermentation of RS with urea could improve the nutritive value and about

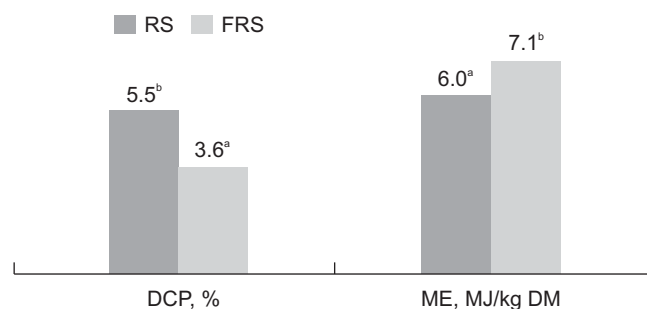


Fig. 1. Natural fermentation of rice straw with urea and nutritive value of diets in buffalo calves. Figures with different superscript in a parameter differ significantly < 0.05

Table 7. Performance of buffalo calves fed naturally fermented rice straw-based diet

Parameter	RS	FRS	Pooled SE
Initial BW, kg	81.7	80.7	14.05
Final BW, kg	101.7	110.7	15.47
Gain in BW, kg	20.0	30.0	3.19
Gain, g/d	166.7	250.0	26.6

RS, Untreated rice straw; FRS, fermented rice straw.

70% of deoiled mustard cake could be spared for the feeding to other productive animals.

REFERENCES

- Anonymous. 2007. *Statistical Abstracts of Punjab*. Economic Advisor to Government of Punjab, Chandigarh.
- AOAC. 1995. *Official Methods of Analysis*. 16th edn. Association of Official Analytical Chemists, Washington, DC.
- Bakshi M P S and Langar P N. 1990. Effect of feeding naturally fermented wheat straw on the availability of nutrients and growth of buffalo calves. *Proceedings National Symposium Buffalo Development for Economic Returns* 23–27.
- Bakshi M P S and Langar P N. 1994. Utilization of naturally fermented urea-crop residues in buffalo production. *Buffalo Journal* 10: 19–27.
- Bakshi M P S and Wadhwa M. 2001. Nutritive evaluation of inoculated fermented wheat straw as complete feed for buffaloes. *Indian Journal of Animal Sciences* 71: 710–11.
- Bakshi M P S, Gupta V K and Langar P N. 1986. Fermented straw as complete basal ration for ruminants. *Agricultural Wastes* 16: 37–46.
- Bakshi M P S, Gupta V K and Langar P N. 1987. Effect of moisture level on the chemical composition and nutritive value of fermented straw. *Biological Wastes* 21: 283–89.
- Barnett A J G and Reid R L. 1957. Studies on the production of volatile fatty acids from the grass in artificial rumen. 1. Volatile fatty acid production from fresh grass. *Journal of Agricultural Science* 46: 315–18.
- Broster W H and Oldham J D. 1981. *Recent Developments in Ruminant Nutrition*. Pp. 194–99. (Eds) Hariesign W and Cole D J A. Butterworths, London.
- Cline J H, Hershberger T V and Bantely O G. 1958. Utilization and/or synthesis of valeric acid during digestion of glucose, starch and cellulose by rumen microorganisms *in vitro*. *Journal of Animal Sciences* 17: 284–92.
- Crampton E W and Maynard L A. 1938. The relation of cellulose and lignin content to the nutritive value of animal feeds. *Journal of Nutrition* 15: 383–95.
- Dia-Da-Silva A A and Sundstol F. 1986. Urea as a source of ammonia for improving the nutritive value of wheat straw. *Animal Feed Science and Technology* 14: 67.
- Gupta V K, Bakshi M P S and Langar P N. 1987. Microbiological changes during natural fermentation of urea-wheat straw. *Biological Wastes* 21: 291–99.
- Horten G M J, Nicholson H H and Christensen D A. 1982. Ammonia and sodium hydroxide treatment of wheat straw in the diet for fattening steers. *Animal Feed Science and Technology* 19: 1.
- Kaur K, Kaur J, Wadhwa M and Bakshi M P S. 2007. Natural fermentation of rice straw in bales and stack and its evaluation as feed. *Indian Journal of Animal Nutrition* 24: 88–91.
- Kaur K, Kaur J, Wadhwa M, Balwinder Kumar and Bakshi M P S. 2008. Fermented rice straw as a source of nutrients for ruminants. *Indian Journal of Animal Nutrition* 25: 195–200.
- Makhdoomi A A, Bakshi M P S and Langar P N. 1996. Factors responsible for low crude protein digestibility of naturally fermented urea-wheat straw. *Indian Journal of Animal Sciences* 66: 203–05.
- N R C. 2001. *Nutrient Requirements of Dairy Cattle*. 7th revised edn. National Academy of Sciences. National Research Council, Washington, D.C., USA.
- Robertson J B and Van Soest P J. 1981. The detergent system of analysis and its application to human foods. *The analysis of Dietary Fibre in Foods*. pp. 123–58. (Eds) James WPT and Theander O. Marcel Dekker, Inc., New York.
- Snedecor G W and Cochran W G. 1994. *Statistical Methods*. Oxford and IBH Publications, New Delhi.