FEEDING COMPLETELY MIXED RATIONS BASED ON UNTREATED, UREA OR AMMONIUM BICARBONATE TREATED WHEAT STRAW TO BUFFALO CALVES

Amanat Ali, M. Fatahullah Khan and Muhmmad Ayaz
Animal Nutrition Programme, Animal Sciences Institute, National Agricultural Research Centre, Park Road, Islamabad, Pakistan.

ABSTRACT

Eight young male buffalo calves of Nili-Ravi breed, randomly divided into two groups A and B (4 animals in each) with a mean initial body weight of 115.3 ± 12.4 and 117.0 ± 7.3 kg respectively, were used for this study. Three isonitrogenous and isoenergetic completely mixed rations based on untreated (UWSR), urea-treated (Ur-TWSR) and ammonium bicarbonate treated (Am–TWSR) wheat straw, were prepared. Treatment of chopped wheat straw in mud houses with either urea or ammonium bicarbonate increased its crude protein content from 3.2 (untreated) to 8.7 and 9.5% (for treated) respectively. The feeding trials were conducted in 2 phases. During the 1st phase, the animals were fed Ur-TWSR and Am–TWSR for a period of 63 days. In the 2nd phase UWSR and Ur-TWSR were compared for a period of 76 days. At the end of each experimental phase a digestion trial was conducted. The results indicated that the animals fed Ur-TWSR showed the best average daily liveweight gain (0.72 kg) as compared to both the UWSR (0.59 kg) and Am–TWSR (0.41 kg). The performance of the animals on Am–TWSR was the poorest. No significant differences were observed in the average daily feed intake of animals fed UWSR and Ur-TWSR. The animals fed Am–TWSR consumed significantly ($P < 0.05$) less feed as compared to UWSR and Ur-TWSR. The best feed conversion ratio was observed for the Ur-TWSR. The apparent digestibility coefficients for dry matter, crude protein, crude fibre and ether extract measured by total collection method indicated that Ur-TWSR was significantly ($P<0.05$) better digestible as compared to other rations. The cost per kg liveweight gain in animals fed Ur-TWSR was significantly ($P < 0.05$) less as compared to other rations. It is concluded that buffalo calves can efficiently and economically be raised on completely mixed urea treated wheat straw based rations.

Keywords: Wheat straw, treatment, urea, ammonium bicarbonate, completely mixed rations, feeding, digestibility, buffalo calves.

INTRODUCTION

Cereal straws have traditionally been used as the main feed ingredient for livestock feeding in Pakistan since centuries. These are the major source of cellulose and hemi-cellulose for meeting the energy needs of ruminants. The performance of the animals however declines when straws are fed as the only staple feed source. This is because of their low nitrogen content, poor digestibility and low voluntary intake, which cannot even meet the maintenance requirement of the animals (Sundstol and Owen, 1984; Ali, 1986; Jung *et al.*, 1993; Schiere, 1993). Studies have shown that the voluntary intake and nutritional value of straw can be improved either through different treatment processes or supplementing with some concentrate or combining both the processes (Ali and Gilani, 1992; Fike *et al.*, 1995; Flachowsky *et al.*, 1995; Oostings *et al.* 1995; Chaudhry, 1998; 2000). Although the treatment of straw with sodium hydroxide or aqueous ammonia improves its digestibility and voluntary intake substantially, the processes have some limitations for their farm level application in developing countries. The ammoniation of straw with urea has proved to be a simple, economical and more viable process for its farm level application (Saadullah *et al.*, 1981; Ali, 1986, Dias-da-Silva and Sundstol, 1986; Makkar and Singh, 1987; Joy *et al.*, 1992; Schiere and Nell, 1993; Taiwo *et al.*, 1995).

Variable responses were observed in the liveweight gain of animals when untreated or ammoniated straw was supplemented with other feed ingredients. (Sundstol and Owen, 1984; Perdock and Leng, 1986; 1990; Zorilla-Rios *et al.*, 1991a, b). An overall improvement in the growth performance of cow calves was observed when urea treated wheat straw was fed as compared to untreated straw supplemented with urea (Shah *et al.*, 1986). Reddy *et al.* (1989) reported that urea or ammonia treated sorghum straw based isonitrogenous complete diets increased the intake and digestibility of dry matter,

organic matter, crude protein and nitrogen free extract (NFE) in crossbred cattle as compared to untreated straw. Orskov *et al.* (1991) concluded that large proportions of treated straw could be incorporated into completely mixed formula diets for finishing cattle with high rates of liveweight gain. Jabbar *et al.* (1993) reported that male buffalo calves gained higher daily body weight and showed a better feed conversion when fed a ration containing 35% of urea treated rice straw as compared to untreated straw based ration. Ramachandra (1997) observed higher body weight gains in heifers fed urea-ammoniated ragi straw as compared to those fed untreated straw with an appropriate quantity of concentrate mixture.

There is still a paucity of information on the utilization of completely mixed rations based on untreated and treated wheat straw for growing and finishing buffalo calves. The present study was therefore conducted to evaluate the efficiency of their utilization in growth and digestibility trials on male buffalo calves.

MATERIALS AND METHODS

Three isocaloric and isonitrogenous completely mixed rations, based on untreated (UWSR), urea treated (Ur-TWSR) and ammonium bicarbonate treated (Am-TWSR) wheat straw, were prepared (Table 1). The proximate chemical composition of the rations as determined by the methods of AOAC (1984) is given in Table 2. The treatment of straw was carried out in mud houses as described by Ali (1986). For this purpose chopped wheat straw (4-5 cm long) was treated with either 4 kg of urea or 5.4 kg of ammonium bicarbonate plus 10 kg of fresh cattle manure (as a source of urease) and 40 kg of water per 100 kg of straw, for a period of 6 weeks.

Table 1: Composition of the experimental rations (%)

Ingredients	UWSR	Ur-TWSR	Am-TWSR
Untreated wheat straw	30.0	--	--
Urea-treated wheat straw	--	30.0	--
NH_4HCO_3-treated wheat straw	--	--	30.0
Rice polishing	25.0	20.0	20.0
Wheat bran	15.0	29.0	19.0
Maize gluten feed	4.5	5.2	12.0
Cane molasses	15.0	15.0	15.0
Mustard seed cake	--	--	3.2
Cotton seed cake	9.00	--	--
Urea	1.00	0.3	0.3
Limestone	0.5	0.5	0.5
Total	**100.0**	**100.0**	**100.0**
Cost per Kg feed as such (in Pak. Rs.)	2.38	2.41	2.77
Cost per Kg feed dry matter (in Pak. Rs.)	2.72	2.75	3.19

UWSR = Untreated wheat straw ration
Ur-TWSR = Urea treated wheat straw ration
Am-TWSR = Ammonium bicarbonate treated wheat straw ration

Table 2: Chemical composition of the experimental rations (on % dry matter basis)

Parameters	UWSR	Ur-TWSR	Am-TWSR
Dry matter (%)	87.5	87.6	86.9
Crude protein	13.5	13.9	13.7
Ether extract	2.7	2.8	3.0
Crude fibre	21.7	18.5	19.2
Total ash	8.4	9.2	9.1
Nitrogen free extract (NFE)	53.7	55.6	54.9
Total digestible nutrients (TDN)	65.8	69.7	67.3

Eight young growing male buffalo calves of Nili-Ravi breed were used in this study. They were randomly divided into two groups A and B (4 animals in each) with a mean initial body weight of 115.3 ± 12.4 and 117 ± 7.3 kg, respectively. The study was conducted in 2 phases. During the 1st phase, the animals in groups A and B were fed Ur-TWSR and Am-TWSR for a period of 63 days respectively. In the 2nd phase, UWSR and Ur-TWSR were compared during a 76 days feeding trial. All the animals were treated against ecto and endo parasites before the start of the experiment. The animals were given a 14 days adaptation period in both the phases before the actual start of the experiment. Daily feed intake and fortnightly weight gains were recorded. At the end of each experimental phase, a 7 days digestion trial was conducted using the total collection method as described by Schneider and Flatt (1975). Representative samples of feeds, orts and faeces were analysed for their proximate chemical composition according to the methods of AOAC (1984). The data were subjected to statistical analysis using the analysis of variance technique according to Snedecor and Cochran (1989).

RESULTS

Treatment of chopped wheat straw in mud houses with either urea or ammonium bicarbonate increased its crude protein content from 3.2 (untreated) to 8.7 and 9.5% (for treated) respectively. The data on the effect of feeding Ur-TWSR and Am-TWSR on the growth performance of buffalo calves are given in Table 3. The results indicated that the average daily feed intake, liveweight gain and

Table 3: Effect of feeding Ur-TWSR and Am-TWSR on weight gain, feed intake and feed conversion ratio in buffalo calves

Parameters	Ur-TWSR	Am-TWSR
Initial weight (Kg)	115.3 ± 12.4	117.3 ± 7.3
Final weight (Kg)	160.7 ± 19.0[a]	143.0 ± 7.0[b]
Average total weight gain (Kg)	45.4 ± 7.0[a]	25.7 ± 8.0[b]
Average daily weight gain (Kg)	0.72 ± 0.12[a]	0.41 ± 0.15[b]
Average daily feed dry matter intake (Kg)	4.96 ± 0.15[a]	3.82 ± 0.16[b]
Feed conversion ratio (FCR)	6.89 ± 0.76[b]	9.32 ± 2.43[a]
Feed cost per Kg gain (in Pak. Rupees)	18.95[b]	29.73[a]

a, b, c = Different superscripts in the same row means significantly different at 5% level

Table 4: Effect of feeding UWSR and Ur-TWSR on weight gain, feed intake and feed conversion ratio in buffalo calves

Parameters	UWSR	Ur-TWSR
Initial weight (kg)	146.7 ± 14.4	167.0 ± 19.0
Final weight (kg)	192.0 ± 6.0[b]	220.0 ± 21.8[a]
Average total weight gain (kg)	45.3 ± 2.0[b]	53.0 ± 7.6[a]
Average daily weight gain (kg)	0.59 ± 0.03[b]	0.70 ± 0.10[a]
Average daily feed dry matter intake (kg)	5.77 ± 0.23	5.75 ± 0.20
Feed conversion ratio (FCR)	9.78 ± 1.31[a]	8.21 ± 0.98[b]
Feed cost per kg gain (in Pak. Rupees)	26.60[a]	22.58[b]

a, b, c = Different superscripts in the same row means significantly different at 5% level

Table 5: Apparent Digestibility Coefficients of UWSR, Ur-TWSR and Am-TWSR (%)

Parameters	UWSR	Ur-TWSR	Am-TWSR	S.E.
Dry matter	64.12[b]	69.40[a]	63.42[b]	± 1.50
Crude protein	55.76[b]	70.13[a]	55.53[b]	± 1.71
Crude fibre	43.07[b]	49.29[a]	49.61[a]	± 2.68
Ether extract	42.60[c]	71.72[a]	59.26[b]	± 2.53

S.E = Pooled standard error

a, b, c = Different superscripts in the same row means significantly different at 5% level

feed efficiency in calves fed Ur-TWSR were improved as compared to those fed Am–TWSR. The feed cost per kg liveweight gain for calves fed Ur-TWSR was significantly ($P<0.05$) less as compared to Am–TWSR.

The results on the effect of feeding UWSR and Ur-TWSR are presented in Table 4. No significant differences were observed in the average daily feed intake of calves fed both the rations. The calves fed Ur-TWSR however, showed significantly ($P<0.05$) higher average daily weight gain as compared to those fed UWSR. Similarly the feed conversion ratio for Ur-TWSR was significantly ($P<0.05$) better as compared to UWSR. The cost per kg liveweight gain in calves fed Ur-TWSR was also significantly ($P<0.05$) less as compared to those fed UWSR.

The results on the nutrient digestibility of rations are presented in Table 5. Ur-TWSR showed the highest dry matter digestibility as compared to both the other rations. No significant differences were observed in the dry matter digestibility of UWSR and Am-TWSR rations. Similar results were observed for the crude protein digestibility of the rations. The UWSR showed the lowest crude fibre digestibility values as compared to both Ur-TWSR and Am-TWSR, which were not significantly different from each other. Ur-TWSR showed the highest whereas the UWSR showed the lowest ether extract digestibility values.

DISCUSSION

The ammoniation of straw in airtight stacks from the hydrolysis of urea has been reported to increase its crude protein and digestible energy contents (Saadullah *et al.*, 1981; Ali, 1986; Cheema *et al.*, 1991). The treatment of wheat straw in mud houses with urea and ammonium bicarbonate in the present study increased its crude protein content from 3.2 (untreated) to 8.7 and 9.5 % (for treated) respectively. The urea treatment fundamentally affects the neutral detergent fibre (NDF) content of the

straw, which decreases as a result of hemicellulose solublization (Caneque *et al.*, 1998). Shen *et al.* (1998) observed that urea treatment increased the extraction of biogenic silica and hence increased the degradation of cellulose and hemicellulose. An added advantage of this treatment process is that the ammonia released by urea hydrolysis also inhibits the mould growth (Schmidt and Weissbach, 1990). Although all the 3 rations were isonitrogenous and isocaloric, the voluntary intake differed significantly ($P<0.05$). However no significant differences were observed in the dry matter intake of UWSR and Ur-TWSR while the Am-TWSR was significantly less consumed than Ur-TWSR. The increased intake of ammoniated forage is attributed to increased rate of digestion and removal of bulk from the rumen (Birkelo *et al.*, 1986; Zorilla-Rios *et al.*, 1991a, b; Shen *et al.*, 1998). Ammoniated straw has higher metabolizable energy content than untreated straw and can show better associative effect with other feed ingredients in improving the overall nutrient utilization by the animals. Ranilla *et al.* (2001) reported that other forms of nitrogen than ammonia are also needed for maximal growth of fibre digesting ruminal microorganisms. The addition of maize gluten feed and rice polishing in completely mixed rations used in the present study might have provided enough ruminaly-escaped protein to maintain the post ruminal protein status of the animals. It has been suggested that an improved post-ruminal protein status may be involved in increasing the intake of ammoniated roughages. The straw mixed in complete formula diets causes minimum interference with the digestion of cellulosic material. Orskov *et al.* (1991) reported that large amounts of treated straw could be incorporated into completely mixed formula diets for finishing steers. The nitrogen added to the straw through ammoniation has been reported to be efficiently utilized by steers (Zorilla-Rios *et al.*, 1991a). Similar results were observed when urea treated straw diets were fed to lambs (Antongiovanni *et al.*, 1991). The increased nitrogen content of straw by ammoniation through urea hydrolysis suggests that the dry matter and nitrogen intake by ruminants can be enhanced (Taiwo *et al.* 1995). Shah *et al.* (1986) observed significantly better weight gains and feed efficiency in Sahiwal calves fed urea treated wheat straw as compared to untreated straw based ration. The results of the present study indicated that Ur-TWSR showed the maximum weight gain and best feed conversion ratio as compared to UWSR and Am-TWSR. The results are also in line with the findings of Jabbar *et al.* (1993) and Ramachandra (1997). The additional energy from the urea-ammoniated straw could however be partly responsible for the increase in liveweight gain. The lowest weight gain, poor feed efficiency and lower voluntary intake in case of Am-TWSR may be attributed to its poor palatability.

The results on the nutrient digestibility of rations confirm the findings of the feeding trail. The best nutrient digestibility for dry matter, crude protein, crude fibre, and ether extract was observed for the Ur-TWSR. Although no significant differences were observed in the dry matter digestibility of UWSR and Am-TWSR, the decreased intake of Am-TWSR might have been responsible for the lower average daily gains and poor feed efficiency. Similar results were observed when untreated and urea treated rice straw was fed to buffalo calves (Cheema *et al.*, 1991). Singh *et al.* (1989) reported that the intake and digestibility of dry matter, crude protein, ether extract, nitrogen free extract and total carbohydrates were higher ($P<0.05$) for the urea treated rice straw diets as compared to untreated straw diets in Murrah buffaloes. Reddy *et al.* (1989) reported that the urea or ammonia treated sorghum straw based isonitrogenous complete diets increased the intake and digestibility of dry matter, organic matter, crude protein and NFE in crossbred cattle as compared to untreated straw. Caneque *et al.* (1998) reported that the in vitro digestibility and degradability of barley straw improved with urea treatment. Shen *et al.* (1998) also observed a significant increase in the in-sacco degradation of different varieties of rice straw after urea treatment. Shah *et al.* (1986) and Jabbar *et al.* (1993) have also reported similar results.

Assessment of cost benefit ratio of feeding completely mixed rations based on untreated and treated straw to growing and finishing buffalo calves is of great significance. The lower feed cost per kg liveweight gain for buffalo calves fed Ur-TWSR indicates its economic feasibility and greater scope for the production of good quality cheaper beef in the country.

REFERENCES

Ali, A., 1986. Rice straw: a potential component of livestock feed. Progressive Farming, 6: 87-91.

Ali, A., and A.H. Gilani, 1992. Effect of different levels of moisture, alkali and urea treatments on the nutritive value of rice straw. Pakistan Vet. J., 12: 129-133.

AOAC, 1984. Official Method of Analysis (14th Edition). Association of Official Analytical Chemists. Washington, DC.

Antongiovanni, M., A. Acciaioli, F. Grifoni, A. Martini and P. Ponzetta, 1991. Effects of wheat straw treated with ammonia from urea hydrolysis in lambs diet. Small Ruminant Res., 6: 39-47.

Birkelo, C.P., D.E. Johnson and G.M. Ward, 1986. Net energy value of ammoniated wheat straw. J. Anim. Sci., 63: 2044-2052.

Caneque, V., S. Velasco, J.L. Sancha, C. Manzanares and O. Souza, 1998. Effect of moisture and temperature on the degradability of fibre and on nitrogen fractions in barley straw treated with urea. Anim. Feed Sci. Technol., 74: 241-258.

Chaudhry, A.S., 1998. Biological and chemical procedures to upgrade cereal straws for ruminants. Nutr. Abst. Rev. Series B, 68: 319-331.

Chaudhry, A.S., 2000. Rumen degradation *in sacco* in sheep of wheat straw treated with calcium oxide, sodium hydroxide and sodium hydroxide plus hydrogen peroxide. Anim. Feed Sci. Technol., 83: 313-323.

Cheema, A. U., A. Ali and M. Ayaz, 1991. Improving intake and digestibility of rice straw as ruminant feed by urea treatment. J. Anim. Plant Sci., 1: 6-9.

Dias-da-Silva, A.A. and F. Sundstol, 1986. Urea as a source of ammonia for improving the nutritive value of wheat straw. Anim. Feed Sci. Technol., 14: 67-79.

Fike, G.D., D.D. Simms, R.C. Cochran, E.S. Vanzant, G.L. Kuhl and R.T. Brandt Jr., 1995. Protein supplementation of ammoniated wheat straw: effect on performance and forage utilization of beef cattle. J. Anim. Sci., 73: 1595-1601.

Flachowsky, G., W.I. Ochrimenko, M. Schneider and G.H. Richter, 1995. Evaluation of straw treatment with ammonia sources on growing bulls. Anim. Feed Sci. Technol., 60: 117-130.

Jabbar, M.A., T. Iqbal and I. Haq, 1993. Effect of feeding untreated and urea treated rice straw for fattening of male buffalo calves. 14th Annual Report, Livestock Production and Research Institute, Bahadarnagar, Okara, Pakistan. pp. 124-125.

Joy, M., S. Alibes and F. Munoz, 1992. Chemical treatment of lignocellulosic residues with urea. Anim. Feed Sci. Technol., 38: 319-333.

Jung, H.G., D.R. Buxton, R.D. Hatfield and J. Ralph, 1993. Forages cell wall structure and digestibility. Am. Soc. Agron., Wisconsin, USA.

Makkar, H.P. and B. Singh, 1987. Kinetics of urea hydrolysis and binding of ammonia to wheat straw during ammoniation by urea. J. Dairy Sci., 70: 1313-1317.

Orskov, E.R., G.W. Reid and M. Kay, 1991. Influence of straw quality and level of concentrate in a completely mixed diet on intake and growth rate in steers. Anim. Prod., 52: 461-464.

Oosting, S.J., J. Van Bruchem and X.B. Chen, 1995. Intake, digestion and small intestinal protein availability in sheep in relation to ammoniation of wheat straw with or without protein supplementation. Br. J. Nutr., 74: 347-368.

Perdock, H.B. and R.A. Leng, 1986. Response of growing cattle to ammoniated wheat straw supplemented with urea, bypass protein and broken rice. Proc. Aust. Soc. Anim. Prod., 16: 303-306.

Perdock, H.B. and R.A. Leng, 1990. Effect of supplementation with protein meal on the growth of cattle given a basal diet of untreated or ammoniated rice straw. Asian Austr. J. Anim. Sci., 3: 269-279.

Ramachandra, B., 1997. Effect of feeding urea ammoniated ragi straw on body weight gain of crossbred heifers. Karnataka J. Agri. Sci., 10: 197-201.

Ranilla, M.J., M.D. Carro, S. Lopez, C.J. Newbold, and R.J. Wallace, 2001. Influence of nitrogen source on the fermentation of fibre from barley straw and sugarbeet pulp by ruminal microorganisms in vitro. Br. J. Nutr., 86: 717-724.

Reddy, C.N., M.R. Reddy and G.V.N. Reddy, 1989. Ammoniation of sorghum straw with urea / anhydrous ammonia for improved utilization among crossbred cattle. Indian J. Anim. Sci., 59: 986-990.

Saadullah, M., M. Haque and F. Dolberg, 1981. Effectiveness of ammonification through urea in improving the feeding value of rice straw in ruminants. Trop. Anim. Health Prod., 6: 30-36.

Schiere, J.B. and A.J. Nell, 1993. Feeding of urea treated straw in the tropics. I. A review of its technical principles and economics. Anim. Feed Sci. Technol., 43: 135-147.

Schiere, J.B., 1993. Nutritive value of straw. In: Feeding of ruminants on fibrous crop residues: aspects of treatment, feeding, nutrient evaluation, research and extension (Editors: Singh, G.P., S.J. Oostings and J. Kiran-Singh). Proceedings of an International Workshop, Karnal, Haryana, India. February 4-8, 1991. Indian Council of Agricultural Research (ICAR), New Delhi, India. pp. 141-146.

Schmidt, L. and F. Weissbach, 1990. Untersuchungen zum Futterwert von harstoffbehandeltem Feuchtstroh. 1. Ergebnisse zum Futterwert. Arch. Tierernaehrung, 40: 739-751.

Schneider, W.H. and J.P. Flatt, 1975. The evaluation of feeds through digestibility experiments. The University of Georgia Press, Athens, Georgia, USA.

Shah, S.B.A, N. Abmed and T. Khan, 1986. Ammoniation of wheat straw under village condition using soybean as additive. Sarhad J. Agric., 2: 321-325.

Shen, H.S., F. Sundstol and D.B. Ni, 1998. Studies on untreated and urea treated rice straw from three cultivation seasons. 2. Evaluation of straw quality through in vitro gas production and *in sacco* degradation measurements. Anim. Feed Sci. Technol., 74: 193-212.

Singh, A.K., G. Rajan, B.S. Gupta and J.P. Srivastava, 1989. Palatability and nutritive value of urea/ammonia treated paddy straw in buffalo calves. J. Res. Birsa Agric. Univ, 1: 91-94.

Snedecor, G.W., W.G. Cochran, 1989. Statistical Methods. 8th Edition. The Iowa State University Press, Ames, Iowa, USA.

Sundstol, F. and E. Owen, 1984. Straw and other fibrous by-products as feed. Elsevier, Amsterdam.

Taiwo, A.A., E.A. Adebowale, J.F.D. Greenhalgh and A.O. Akinsoyinu, 1995. Techniques for trapping ammonia generated from urea treatment of barley straw. Anim. Feed Sci. Technol., 56: 133-141.

Zorrilla-Rios, J., G.W. Horn and R.W. McNew, 1991a. Nutritive value of ammoniated wheat straw fed to cattle. J. Anim. Sci., 69: 283-284.

Zorrilla-Rios, J., G.W. Horn, W.A. Phillips and R.W. McNew, 1991b. Energy and protein supplementation of ammoniated wheat straw diets for growing steers. J. Anim. Sci., 69: 1809-1819.