Growth and Nutrient Utilization in Buffalo Calves Fed Urea-ammoniated Wheat Straw and Hydrochloric Acid plus Urea Treated Wheat Straw

P. V. Nair, A. K. Verma, R. S. Dass* and U. R. Mehra
Animal Nutrition Division, Indian Veterinary Research Institute, Izatnagar 243 122 (UP), India

ABSTRACT: Ten growing male buffalo calves (aged 6-8 months, average body weight 88.2±0.57 kg were divided randomly into two groups. Animals in group I were fed on concentrate mixture A (CP 20.2%, TDN 77.4%) and urea-ammoniated wheat straw (UAWS) while the animals in group II were fed on concentrate mixture B (CP 17.9%, TDN 77.6%) and HCl plus urea treated wheat straw (HCl UAWS) to meet their nutrient requirement for 500 g gain/d as per Kearl (1982). This feeding practice lasted for 120 days, during which fortnightly body weight were recorded to assess their growth rate. A metabolism trial was conducted after 90 days of experimental feeding to compare the digestibility of nutrients, their balance, plane of nutrition and relative cost of feeding in two groups of animals. Results revealed a significant increase in the CP content of ammoniated wheat straw due to addition of HCl viz. 12.1% from 7.5%. There was a decrease in the intake of DM (p<0.05), OM (p<0.05), EE (p<0.05), NDF (p<0.01), ADF (p<0.01), cellulose (p<0.01) and hemicellulose (p<0.01) in group II as compared to group I. The digestibility (%) of DM, OM and CP was significantly (p<0.01) more in group II, whereas the digestibility (%) was significantly more for NDF (p<0.05) and hemicellulose (p<0.01) in group I than group II. There was no significant difference in the N, Ca and P balance in two groups. Intake of total DM (g/d) or (g/kg W0.75) was significantly (p<0.01) more in UAWS fed group as compared to HCl UAWS fed group. Feeding cost (Rs./kg. weight gain) was significantly (p<0.05) more in group II as compared to group I. It is concluded that HCl UAWS is not suitable for the feeding of growing buffalo calves as it reduced the growth rate in comparison to UAWS fed buffalo calves. (Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 5 : 682-686)

Key Words: Buffalo Calves, Urea-Ammoniation, Hydrochloric Acid, Urea Ammoniated Wheat Straw, Growth

INTRODUCTION

Feeding of animals in the third world countries is totally dependent upon agricultural crop residues, which are low in essential nutrients like protein, minerals and vitamins, as well as poor in palatability and digestibility. The cause of poor digestibility of crop residues has been earmarked to the presence of lignin as ligno-cellulose complex, which is resistant to the enzymes secreted by the mammalian tissues as well as rumen microbes. Out of the various chemicals used to break this complex, urea-ammoniation of the crop residues has been found beneficial as it improves the palatability, digestibility and also adds a significant amount of nitrogen, a deficient nutrient in the crop residues (Mehra et al., 1989; Dass et al., 1993 a,b; Khan et al., 1999; Rath et al., 2001). The process of urea ammoniation of crop residues is simple and can easily be adopted by the farmers/livestock owners. The only drawback of the method is extensive loss of urea-ammonia, which may be as high as 60-70% (Dass et al., 2000,2001) which is not a significant loss of the valuable nutrient but ammonia escaped to the atmosphere also pollute the environment. Various workers have used some organic (acetic acid, phosphoric acid and formic acid) and inorganic acids (boric acid, hydrochloric acid and sulphuric acid) to fix this excess ammonia (Borhami et al., 1982; Cloette and Kritzinger, 1984; Yadav and Virk, 1993a,b; Dass et al., 2000) with different degree of ammonia fixation. Recently Dass et al. (2001) treated the wheat straw with urea and hydrochloric acid simultaneously to trap 30% of the ammonia evolved from 4% urea and got significant increase in CP content of the wheat straw.

The objective of this study was to compare the effect of feeding urea treated and hydrochloric acid plus urea treated wheat straw on the growth and nutrient utilization in growing male buffalo calves.
assigned to two equal groups in a completely randomized design, after deworming, vaccination and acclimatization to the new environment for a period of one month. The buffalo calves were housed individually in well ventilated cement floored shed having individual feeding facilities and reared under proper hygienic and uniform managemental conditions. Buffalo calves in group I were offered urea-ammoniated wheat straw (UAWS) plus concentrate mixture A, while the animals in group II were offered HCl treated ammoniated wheat straw (HCl UAWS) plus concentrate mixture B to meet their nutrient requirement for 500 g gain/day as per Kearl (1982). Concentrate to roughage ratio was kept as 50:50 in both the groups and animals were fed at 9:30 AM throughout the experimental feeding of 120 days. All the animals were weighed at fortnightly interval to assess their growth rate and for readjusting the feeding schedule. Clean and fresh water was provided ad libitum daily.

Metabolism trial
In order to determine the digestibility and balance of nutrients, a metabolism trial of six days duration involving daily collection of faeces and urine and recording of feed and residue was carried out after 90 days of experimental feeding on all the animals by harnessing them in the metallic cages. Faeces voided and urine excreted by each individual animal were recorded at 10 AM daily. Faeces pooled in preweighed plastic buckets in 24 h were mixed thoroughly in a large plastic trough and a representative sample was taken to the laboratory for aliquoting and analysis. Urine collected through a tray kept under each metabolic cage was stored in a plastic bottle. To avoid loss of ammonia-N, 10 ml of 1:4 HCl was sprinkled on the tray daily. Representative sample of feed offered and residues left were taken daily for dry matter estimation and proximate analysis.

Analysis of samples
The feed and faecal samples were analysed for proximate composition (AOAC, 1980), neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Van Soest et al., 1991). Hemicellulose and cellulose were calculated as NDF-ADF and ADF-ADL respectively.

Nitrogen in urine was determined by the Kjeldahl N method (AOAC, 1980). Calcium in feed, faeces and urine was estimated as per the method of Talapatra et al. (1940), while phosphorous was determined colorimetrically using molybdovanadate reagent as per AOAC (1990). The data were analysed statistically using standard t test as discussed by Snedecor and Cochran (1967).

RESULTS AND DISCUSSION

The physical and chemical composition of ration ingredients is presented in table 1. Urea ammoniation of wheat straw increased the crude protein (CP) content to 7.5 percent, which further increased to 12.10 percent in HCl plus urea treated wheat straw. This may be due to the formation of ammonium chloride. Earlier workers have also reported similar increase in CP content after the addition of acids to the ammoniated straw (Borhami et al., 1982; Cloette and Kritzinger, 1984; Yadav and Virk, 1994 a,b; Taiwo et al., 1995; Dass et al., 2000, 2001 and Mehra et al., 2001). Total intake, and digestibility of dry matter and various other nutrients are presented in table 2. Intake (g/d) of dry matter (DMI) and organic matter (OMI) were significantly (p<0.05) more in group I as compared to group II. Similarly, the intake (g/d) of ether extract (EEI), neutral detergent fiber (NDFI), acid detergent fiber (ADFI), cellulose and hemicellulose (HCl) were significantly (p<0.01) more in group I as compared to group II, whereas the intake of crude protein (CP) was statistically alike in both groups. The lower intake of DM vis-a-vis other nutrients may be due to the acidic pH of the straw as reported by Cloettle and Kritzinger (1984), who also observed an adverse effect of the higher (50%) acid fixation level on the voluntary dry matter intake. Contrary to this Borhami et al., (1982) did not find any significant difference in dry matter intake in sheep fed with ammoniated straw or ammoniated straw sprayed with formic or acetic acid. Similarly Yadav and Virk (1994 a,b) observed no difference in dry matter intake in buffalo calves fed on ammoniated straw and

| Attributes                  | Conc. | Conc. | UAWS | HCl |
|-----------------------------|-------|-------|------|-----|
|                | Mix. A | Mix. B | UAWS | HCl |
| Formular composition (percent as fed basis) |       |       |      |     |
| Ingredients                |       |       |      |     |
| Wheat bran                | 7     | 12    |      |     |
| Crushed maize             | 62    | 66    |      |     |
| Soyabean cake             | 28    | 19    |      |     |
| Mineral mixture           | 2     | 2     |      |     |
| Common salt               | 1     | 1     |      |     |
| *Vitablend (AD3)g/100 kg  | 25    | 25    |      |     |

| Chemical composition (percent DM basis) |
|----------------------------------------|
| Organic matter                        | 92.0 | 94.5 | 6.9  | 91.1 |
| Crude protein                         | 20.3 | 17.9 | 7.5  | 12.1 |
| Ether extract                         | 5.6  | 4.8  | 0.9  | 0.8  |
| Neutral detergent fiber               | 28.0 | 22.2 | 85.0 | 78.0 |
| Acid detergent fiber                  | 5.8  | 5.6  | 63.7 | 60.1 |
| Cellulose                             | 3.8  | 3.9  | 44.6 | 46.6 |
| Hemicellulose                         | 22.2 | 16.5 | 21.2 | 17.9 |
| Calcium                               | 1.6  | 1.2  | 0.57 | 0.54 |
| Phosphorus                            | 0.7  | 0.6  | 0.13 | 0.14 |

*Vitablend contained Vitamin A (50,000 I.U./g) and D3 (5,000 I.U./g).
ammoniated straw treated with sulphuric acid. The digestibility (%) was significantly more of DM (p<0.05), OM (p<0.01) in group II as compared to group I, whereas the digestibility of hemicellulose was significantly (p<0.05) more in group I as compared to group II. Similar higher digestibility of DM, OM and CP was reported earlier by Dass et al. (2001) in adult buffaloes fed ammoniated straw treated with sulphuric acid. The intake and excretion of Ca through feces were significantly (p<0.01) more in group I as compared to group II, where the excretion of calcium through urine (g/d) and its positive balance in both the groups were statistically alike. Like the calcium, intake of P was significantly (p<0.05) more in group I (635.0 g/d) as compared to group II. Similarly the average daily gain (g/d) was significantly (p<0.05) more weight gain in group I as compared to group II, 120 days of experimental feeding, indicating a significantly higher gain in two groups was 76.2 and 55.6 kg respectively in both groups. The total body weight of animals is presented in table 4. The total body weight was recorded, but similar to the results reported by the same authors in adult buffaloes fed on HCl UAWS plus barley grain. The intake and excretion of Ca and P in sheep fed pelleted food supplemented with HCl or H2SO4 or mixture of HCl and H2SO4 (1:1). They observed negative Ca and P balance in sheep, where the diet was treated with acid.

Though the excretion of N through feces was significantly (p<0.01) more in group I, but animals in both the groups were in positive N balance having no statistical significant difference. These results are contrary to the results reported by Dass et al. (2001) in adult buffaloes fed ammoniated straw sprayed with HCl, where a negative N balance was recorded, but similar to the results reported by the same authors in adult buffaloes fed on HCl UAWS plus barley grain. The intake and excretion of Ca through feces were significantly (p<0.01) more in group I as compared to group II, where the excretion of calcium through urine (g/d) and its positive balance in both the groups were statistically alike. Like the calcium, intake of P was significantly (p<0.05) more in group I as compared to group II. The excretion of P through feces and urine and its balance were statistically similar in two groups. These results of mineral balance are similar to the observation of Dass et al., 2001 and Mehra et al., 2001 in adult buffaloes fed HCl treated and acetic acid treated UAWS respectively. Contrary to these L’Estrange and Murphy (1972) reported higher excretion of Ca and P in sheep fed pelleted food supplemented with HCl or H2SO4 or mixture of HCl and H2SO4 (1:1). They observed negative Ca and P balance in sheep, where the diet was treated with acid.

Body weight gain and plane of nutrition in two groups of animals is presented in table 4. The total body weight gain in two groups was 76.2 and 55.6 kg respectively in 120 days of experimental feeding, indicating a significantly (p<0.05) more weight gain in group I as compared to group II. The excretion of P through feces and urine and its balance were statistically similar in two groups. These results of mineral balance are similar to the observation of Dass et al., 2001 and Mehra et al., 2001 in adult buffaloes fed HCl treated and acetic acid treated UAWS respectively. Contrary to these L’Estrange and Murphy (1972) reported higher excretion of Ca and P in sheep fed pelleted food supplemented with HCl or H2SO4 or mixture of HCl and H2SO4 (1:1). They observed negative Ca and P balance in sheep, where the diet was treated with acid.

Body weight gain and plane of nutrition in two groups of animals is presented in table 4. The total body weight gain in two groups was 76.2 and 55.6 kg respectively in 120 days of experimental feeding, indicating a significantly (p<0.05) more weight gain in group I as compared to group II. The excretion of P through feces and urine and its balance were statistically similar in two groups. These results of mineral balance are similar to the observation of Dass et al., 2001 and Mehra et al., 2001 in adult buffaloes fed HCl treated and acetic acid treated UAWS respectively. Contrary to these L’Estrange and Murphy (1972) reported higher excretion of Ca and P in sheep fed pelleted food supplemented with HCl or H2SO4 or mixture of HCl and H2SO4 (1:1). They observed negative Ca and P balance in sheep, where the diet was treated with acid.

Table 2. Intake and digestibility of various nutrients in buffalo calves fed UAWS and HCl UAWS

| Attribute                          | Group I                  | Group II                 |
|------------------------------------|--------------------------|--------------------------|
| Dry matter intake through          | 1,693.1±154.5            | 1,622.4±105.4            |
| Concentrate mixture A/B            | 1,941.8±97.8             | 909.5±37.8               |
| UAWS/UAWS                          | 3,634.9±341.7            | 2,531.9±104.7            |
| Digestibility (%)**                | 57.2±10.5                | 64.4±0.9                 |
| Organic matter                     |                          |                          |
| Intake (g/d)*                      | 3,253.1±302.7            | 2,365.2±178.7            |
| Digestibility (%)**                | 61.8±1.42                | 67.7±0.74                |
| Crude protein                      |                          |                          |
| Intake (g/d)                       | 491.5±44.7               | 403.6±28.2               |
| Digestibility (%)**                | 51.6±2.26                | 66.1±1.24                |
| Ether extract                      |                          |                          |
| Intake (g/d)*                      | 113.3±10.15              | 86.9±5.37                |
| Digestibility (%)                  | 64.9±7.68                | 71.7±1.80                |
| Neutral detergent fiber            |                          |                          |
| Intake (g/d)**                     | 2,086.7±213.8            | 1,067.5±107.0            |
| Digestibility (%)*                 | 56.3±2.5                 | 50.2±1.7                 |
| Acid detergent fiber               |                          |                          |
| Intake (g/d)**                     | 1,331.7±134.1            | 618.5±77.2               |
| Digestibility (%)                  | 45.0±3.7                 | 40.0±2.9                 |
| Cellulose                          |                          |                          |
| Intake (g/d)**                     | 926.1±93.6               | 484.9±58.1               |
| Digestibility (%)                  | 66.3±2.67                | 61.4±1.85                |
| Hemicellulose                      |                          |                          |
| Intake (g/d)**                     | 790.9±73.7               | 440.6±23.7               |
| Digestibility (%)**                | 77.4±3.79                | 63.1±2.38                |

* p<0.05, ** p<0.01.

Table 3. Intake, excretion and balance of nitrogen, calcium and phosphorus in group I and II

| Attribute                          | Group I                  | Group II                 |
|------------------------------------|--------------------------|--------------------------|
| Nitrogen intake (g/d)              | 78.45±7.15               | 64.58±4.51               |
| N out go through                   |                          |                          |
| Feces (g/d)                        | 37.36±1.59               | 22.05±2.28               |
| Urine (g/d)                        | 20.93±2.72               | 19.74±1.01               |
| N balance (g/d)                    | 20.16±4.22               | 22.79±2.97               |
| Calcium intake (g/d)**             | 41.05±3.83               | 25.63±1.84               |
| Ca outgo through                   |                          |                          |
| Feces (g/d)**                      | 31.29±2.25               | 18.68±1.91               |
| Urine (g/d)                        | 6.00±0.76                | 4.80±0.80                |
| Ca balance (g/d)                   | 3.76±1.80                | 2.15±0.47                |
| Phosphorus intake (g/d)*           | 14.81±1.34               | 10.53±0.67               |
| P out go through                   |                          |                          |
| Feces (g/d)                        | 7.36±0.85                | 4.64±0.83                |
| Urine (g/d)                        | 4.20±0.70                | 4.04±0.35                |
| P balance (g/d)                    | 3.25±0.90                | 1.88±0.52                |

* p<0.05, ** p<0.01.

Data on intake, excretion and balance of nitrogen (N), calcium (Ca) and phosphorus (P) is presented in table 3. Nitrogen intake (g/d) was alike statistically in 2 groups.
PERFORMANCE OF BUFFALO CALVES FED AMMONIATED WHEAT STRAW

A growth rate of 635.0 g/d in group I was equivalent to growth rate of 640 g/d reported by Yadav and Virk (1994a) in buffalo calves fed on urea-ammoniated wheat straw having 24% germinated barley, but growth rate was less in group II as compared to the values obtained by the same workers in buffalo calves fed on H2SO4 treated urea ammoniated wheat straw. This may be due to the higher level of urea (7.5%) and low level of acid used (to trap 20% ammonia) by these workers.

There was no significant difference in intake of DCP and TDN in two groups when calculated as such or on the basis of per kg W0.75. The DCP and TDN values of the two diets were 6.8, 56.6 and 10.6, 66.3 percent respectively. The poor growth rate in group II may be due to the low intake of nutrients i.e. DM and TDN, than the requirements as specified by Kearl (1982). Feed cost of live weight gain is presented in Table 5. The feed cost of live weight gain is largely dependent on cost of feed and efficiency of feed utilization. Results revealed no significant difference in the feed cost of concentrate in two groups, indicating the similar nutrient utilization and their metabolism, but the cost of roughage in group II was significantly (p<0.05) lower than group I. This may be due to the poor palatability of HCl UAWS as compared to UAWS (Dass et al., 2001).

**CONCLUSION**

Feeding of hydrochloric acid treated urea ammoniated straw
wheat straw is not suitable for the feeding of growing buffalo calves as it reduced the growth rate in comparison to urea-ammoniated wheat straw fed buffalo calves.

REFERENCES

Association of Official Analytical Chemists. 1980. Official Methods of Analysis; 13th ed. Washington, DC.

Association of Official Analytical Chemists. 1990. Official Methods of Analysis; 15th ed. Washington, DC.

Borhami, B. E. A., F. Sundstol and T. H. Garmo. 1982. Studies on ammonia treated straw. II. Fixation of ammonia in treated straw by spraying with acids. Anim. Feed Sci. Technol. 7:53-59.

Cloette, S. W. P. and N. M. Kritzinger. 1984. The fixation of nitrogen in urea-ammoniated wheat straw by means of different acids. South African J. Anim. Sci. 14(4):173-176.

Dass, R. S., Jai Kishan and U. B. Singh. 1984. Effect of feeding urea (ammonia) treated paddy straw on rumen metabolism in crossbred animals. The Indian J. Nutr. Dietet. 21:342-349.

Dass, R. S., U. R. Mehra and U. B. Singh. 1993a. Effect of acidified sodium sulphite and urea-ammoniation treatment on the utilization of wheat straw by rumen micro-organisms. Indian J. Anim. Sci. 62:324-328.

Dass, R. S., U. R. Mehra, U. B. Singh and G. S. Bisht. 1993b. Degradability of DM and fiber constituents of lingo-cellulosic residues treated with SO2 (evolved from acidified sodium sulphite) and urea/ammonia. World Review of Animal Production 28:55-64.

Dass, R. S., U. R. Mehra and A. K. Verma. 2000. Nitrogen fixation and in situ dry matter and fiber constituents disappearance of wheat straw treated with urea and boric acid in Murrah buffaloes. Asian-Aus. J. Anim. Sci. 13(8):1133-36.

Dass, R. S., A. K. Verma, U. R. Mehra and D. S. Sahu. 2001. Nutrient utilization and rumen fermentation pattern in Murrah buffaloes (Bubalus bubalis) fed urea and urea plus hydrochloric acid treated wheat straw. Asian Aust. J. Anim. Sci. 14(11):1542-1548.

Fahmy, S. T. M. and E. R. Orskov. 1989. Digestion and utilization of straw. Effect of different chemical treatments on degradability and digestibility of barley straw by sheep. Anim. Prod. 38:69-74.

Khan, M. J., J. R. Scaife and F. D. Hovell. 1999. The effect of different sources of urease enzyme on nutritive value of wheat straw treated with urea as source of ammonia Asian-Aus. J. Anim. Sci. 12:1063-1067.

Kearl, L. C. 1982. Nutrient Requirements of Ruminants in Developing countries International Feedstuff Institute, Utah Agricultural Experiment Station, Utah State University, Logan, Utah, USA.

L’Estrange, J. L. and F. Murphy. 1972. Effects of dietary minerals acids on voluntary food intake, digestion, mineral metabolism and acid-base balance of sheep. Br. J. Nutr. 28:1-17.

Mehra, U. R., R. S. Dass, A. K. Verma and D. S. Sahu. 2001. Effect of feeding urea and acetic acid treated wheat straw on the digestibility of nutrients in adult male Murrah buffaloes (Bubalus bubalis). Asian-Aust. J. Anim. Sci. 14(11):1690-1695.

Mehra, U. R., N. N. Pathak, U. B. Singh and R. S. Dass. 1989. Studies on the nutritional improvement of sorghum stover (Jowar kadbi) through ammoniation by urea ensiling. Biological Waste 29:67-71.

Rath, S. S., A. K. Verma, Putan Singh, R. S. Dass and U. R. Mehra. 2001. Performance of growing lambs fed urea-ammoniated and urea supplemented based diets. Asian-Aust. J. Anim. Sci. 14(8):1078-83.

Snedecor, G. W. and W. G. Cochran. 1967. Statistical Methods, 6th edn. Oxford and IBH Publication, Calcutta, India.

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

Talapatra, S. K., S. C. Roy and K. C. Sen. 1940. Estimation of phosphorus, chlorine, calcium, sodium and potassium in food-stuffs. Indian J. Vet. Sci. Anim. Husb. 10:243-258.

Toroitich, M. J. 1992. Minimizing the loss of ammonia during urea treatment of wheat straw for growing calves. M.Sc. Thesis CCC Haryana Agricultural University, Hissar, India.

Van Soest, P. J., J. B. Robertson and B. A. Lewis. 1991. Methods for dietary fiber, neutral detergent fiber and non-starch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3553-3597.

Yadav, B. S. and A. S. Virk. 1994a. The fixation of nitrogen using acid, green forage and germinated barley during urea treatment of straw. Anim. Feed Sci. Technol. 50:123-135.

Yadav, B. S. and A. S. Virk. 1994b. Effect of acid treatment in reducing ammonia loss during urea ammoniation of straw. Indian J. Anim. Sci. 64(7):762-766.