# CRUDE PROTEIN SPARING EFFECT OF AMMONIATED WHEAT STRAW FOR GROWING STEERS

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## Story in Brief

Thirty-two Beefmaster x Hereford-Angus crossbred steers (634 lb) were individually fed for 90 days with untreated wheat straw (US) plus corn-soybean meal (SBM) mix to supply 70 (trt 1), 80 (trt 2) or 100 (trt 3) percent of estimated crude protein requirements for a daily gain of 1.0 lb. A fourth treatment consisted of ammoniated straw (4.4 g $NH_3$/kg straw) supplemented with corn only (trt 4), and fed at a similar dry matter intake as the US treatments. Daily gains (ADG) of steers fed US was linearly increased (P<.01) as SBM supplementation increased, with ADG for trt 4 (AS + corn) being no different than that of steers fed US and the highest level of SBM (trt 3). The crude protein sparing effect with ammoniated wheat straw was comparable to 1.3 lb of SBM. Results are discussed in terms of animal performance and concentrations of ruminal and blood metabolites.

(Key Words: Ammoniation, Wheat Straw, Protein Value, Steers.)

## Introduction

Substantial work has focused on changes in chemical composition, animal performance and overall digestibility of ammoniated crop residues, in particular wheat straw based rations (Horton, 1978). Various levels of supplementation, usually with some source of conventional protein and less frequently, energy (Streeter et al., 1983) have been included in the diet. Estimates of the potential sparing effect of dietary protein as a result of the increased nitrogen content of ammoniated residues is poorly documented in the literature.

The objective of the present study was to estimate the nutritional value of the nitrogen added to wheat straw by ammoniation, in terms of animal performance and rumen and blood metabolites measurements. Soybean meal was used as the reference nitrogen source.

## Materials and Methods

Thirty-two Beefmaster x Hereford-Angus crossbred steers (634 lb) of a common cow herd were individually allocated according to weight to eight blocks of four animals each. Steers within each block were randomly assigned to the four treatments. Three treatments consisted of untreated wheat straw (US), supplemented with soybean meal (SBM) to supply 70 (trt 1), 80 (trt 2) or 100 (trt 3) percent of crude protein requirements for a daily gain of 1 lb. Treatment 4 was ammoniated wheat straw (AS) with no SBM, offered at a similar dry matter (DM)

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intake as that for the US treatments. Ground corn was fed at a level of 6.2 to 7.7 lb/head/day to all steers to meet net energy requirements for the desired level of performance. Minerals and vitamins were included in the supplement to satisfy NRC (1970) requirements for Ca, P, S, Mg, K and vitamins A, D, and E. Straw was ammoniated by the stack method (Sundstol et al., 1978; 4.4 percent $NH_3$ of as-fed straw). Individual daily intakes of straw were calculated by weekly recording of refusals. Initial and final body weights were recorded after withholding feed and water for 18 hours. All steers were fed a maintenance level of alfalfa hay for five days prior to the final shrink. Samples of rumen fluid (stomach tube) and blood plasma (jugular vein) were obtained from each animal at 2, 4 and 8 h after feed had been offered. Rumen fluid was analyzed for pH, ammonia nitrogen concentration ($NH_3$-N, mg/dl) and total volatile fatty acids (TVFA, mmoles/liter). Blood plasma samples were analyzed for total protein (TP, g/dl) and urea (BU/dl).

## Results and Discussion

Results on intakes and animal performance are summarized in Table 1. Total DM intake was similar among treatments, while N intake of steers fed US increased linearly ($P<.01$) with increasing intakes of SBM. The proportion of total DM intake as straw DM and daily gains of steers increased in a linear fashion ($P<.01$) with higher SBM-nitrogen intakes. Average daily gain for trt 4 (AS) was not different from that of trt 3 (US + 1.3 lb/head.day$^{-1}$ of SBM). Therefore, the differences in ADG among treatments can be interpreted as a response to increased intake of N. Increasing the N content of US by ammoniation (4.2 to 11.0 percent), had a sparing effect of 1.3 lb of SBM (50 percent CP, dry matter basis) for 634 lb steers gaining at a rate of 1 lb/day.

**Table 1. Animal performance of steers fed untreated wheat straw (US) and increasing amounts of soybean meal (SBM) or ammoniated wheat straw (AS).**

| Treatments: | 1 | 2 | 3 | 4 | SBM linearity | |
|---|---|---|---|---|---|---|
| Straw type: | US | US | US | AS | (level of | |
| SBM, lb/head/day: | 0 | .385 | 1.3 | 0 | significance) | SEM |
| Total intake, lb/day | | | | | | |
| Dry matter | 13.9 | 14.5 | 14.7 | 14.7 | NS | .2 |
| Straw DM | 7.1 | 7.6 | 7.9 | 7.8 | Not tested | -- |
| Corn DM | 5.6 | 5.3 | 4.5 | 5.7 | Not tested | -- |
| Crude protein | 1.17 | 1.38 | 1.69 | 2.10 | .01 | .02 |
| DM intake, % BW | 2.09 | 2.16 | 2.16 | 2.16 | NS | .03 |
| Straw DM/total, % | 51.0 | 52.6 | 53.7 | 53.5 | .01 | .57 |
| Average daily gain, lb | .616 | .722 | .970 | .990 | .01 | .04 |

Rumen fermentation measurements are shown in Table 2. Time after feeding resulted in a linear reduction ($P<.01$) in ruminal pH and the acetic/propionic acid ratio (Ac/Pr). Total VFA concentrations increased ($P<.01$) with time after feeding. In general, ruminal pH could be considered adequate for microbial activity under high roughage dietary regimes. Treatments had no effect on ruminal pH or Ac/Pr (Table 2). Total VFA concentrations were increased in trt 3 (P<.01), while trt 4 was similar to trt 1 and trt 2. Ruminal $NH_3$-N was influenced by treatments and time after feeding. Treatment 3 showed the highest levels (P<.01). Blood plasma total protein concentrations were not influenced by treatment, nor post-feeding interval (range 7.19 to 7.47 g/dl). Blood urea increased linearly (P<.01) with the inclusion of SBM; AS values resembled those of the medium level of SBM supplementation (trt 2). The lower rumen $NH_3$-N and BU concentrations

**Table 2. Effect of ammoniation of wheat straw and soybean meal supplementation on blood plasma urea and ruminal fermentation measurements at different hours after feeding.**

| Hours after feeding | Treatments | | | Blood urea (mg/dl) | Rumen fluid[3] | | | |
|---|---|---|---|---|---|---|---|---|
| | Straw type[1] | SBM ($lb/h.d^{-1}$) | OBS[2] | | pH | $NH_3$-N (mg/dl) | TVA (mMoles/L) | Ac/Pr |
| 2 | US | 0 | 8 | 3.07[a][4] | 6.98 | 2.71[a] | 60.9 | 4.5 |
| | US | .385 | 8 | 8.38[b] | 7.00 | 5.02[b] | 55.3 | 4.3 |
| | US | 1.3 | 7 | 15.77[c] | 7.05 | 10.88[d] | 64.3 | 4.6 |
| | AS | 0 | 8 | 5.79[ab] | 7.03 | 8.74[c] | 59.4 | 4.7 |
| | SE | | | .33 | .06 | .65 | 3.0 | .27 |
| 4 | US | 0 | 8 | 5.94[a] | 6.88 | 2.25[a] | 67.0 | 4.0 |
| | US | .385 | 8 | 14.21[b] | 6.86 | 2.49[a] | 65.7 | 3.9 |
| | US | 1.3 | 7 | 25.79[c] | 6.93 | 9.01[b] | 75.6 | 3.8 |
| | AS | 0 | 8 | 13.45[b] | 6.91 | 9.00[b] | 72.2 | 4.4 |
| | SE | | | .82 | .05 | 1.01 | 3.4 | .31 |
| 8 | US | 0 | 8 | 1.93[a] | 6.64 | .91[a] | 73.3[ab] | 2.9 |
| | US | .385 | 8 | 3.63[ab] | 6.58 | 1.98[a] | 73.0[ab] | 3.8 |
| | US | 1.3 | 7 | 9.70[c] | 6.45 | 6.80[b] | 81.0[b] | 3.0 |
| | AS | 0 | 8 | 4.05[b] | 6.72 | 2.50[a] | 69.6[a] | 4.3 |
| | SE | | | .21 | .09 | .80 | 3.4 | .56 |

[1]Straw type: US = untreated; AS = ammoniated.
[2]OBS = Number of observations.
[3]$NH_3$-N = ammonia nitrogen; TVFA = total volatile fatty acids; Ac/Pr = Acetic/Propionic.
[4]Means in a column for each hour with different superscripts are different at: a,b,c,d, P<.01.

observed in the AS diets (trt 4) as compared to the highest level of SBM supplementation to US diet (trt 3) may reflect a greater uptake of nitrogen by ruminal bacteria. By this mechanism, the nitrogen added to the ammoniated straw becomes of nutritional value to the host animal. The degree to which conventional protein can be spared by ammoniation will depend to some extent on other nutritional and physiological factors that may influence ruminal microbial activity. Nevertheless, under conditions where no energy or mineral deficiencies are apparent, it may be considered that for growing steers gaining at a rate of 1 lb/day, no supplementary nitrogen from conventional sources of protein are required if ammoniated wheat straw represents 50 percent of the total daily dry matter intake.

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