# CARCASS CHARACTERISTICS AND BEEF PALATABILITY AS INFLUENCED BY FEEDING RICE STRAW AND ALFALFA

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## Summary

Ninety feeder steers, predominantly Herefords weighing 280 kg, were assigned at random to each of nine diets: basal (high concentrate); 25 or 50% of untreated rice straw (25- or 50 URS) or ammoniated rice straw (25- or 50 ARS); a 50:50 mixture of URS - alfalfa or ARS - alfalfa replacing a proportion of the basal at 25 and 50%. Animals were slaughtered after 154 or 161 days of feeding. The cattle fed 50% URS had the lowest ($P < .05$) carcass weight, dressing & external fat thickness, kidney, pelvic and heart fat, rib eye area, marbling score, quality and yield grades, followed by cattle fed 50% ARS, 50% rice straw/alfalfa, and 25% rice straw alone or 25% rice straw/alfalfa mixture. Ammoniation of rice straw improved all measured traits. A 25% substitution of basal diet with untreated or ammoniated rice straw and a 50% substitution with rice straw/alfalfa mixture did not significantly affect carcass traits compared to the basal group. Only 50% ARS and 50% URS cattle showed differences in body composition ($p < .05$) with lower fat and higher water and protein contents. No significant differences were found in shear value, panel tenderness, connective tissue, juiciness, flavor and overall palatability of meat from steers fed the basal, ARS or URS diets.
(Key Words: Rice Straw, Alfalfa, Carcass Traits, Body Composition, Palatability)

## Introduction

Researchers continue to examine the effects of dietary energy on growth rate, carcass composition and meat palatability. In general, finishing cattle on high energy or grain diets results in a higher rate of gain, higher dressing percentage, larger rib-eye area, more carcass fat, higher quality grade and higher yield grade number (Moody, 1976; Aberle et al., 1981). Furthermore, meat from cattle finished on high energy diets is generally more tender, more desirable in flavor and more satisfactory in overall palatability than meat from cattle finished on low energy diets (Bowling et al., 1977; Harrison et al., 1978; Aberle et al., 1981). This observation was generally true when the animals were fed high or low energy diets for a constant time and slaughtered at constant age. When the animals were finished to the same quality grade or identical market weight, however, types of diets had little influence on organoleptic quality of meat (Bidner, 1975; Schupp et al., 1976).

Rice straw is one of the most abundant crop residues in many countries. The major problems associated with the use of rice straw as an animal feed are low nutrient content and poor digestibility. Various chemical treatments can improve the nutritive value of rice straw. Ammoniation has been one of the most commonly used chemical procedures to improve utilization of crop residues as feedstuffs for ruminants. Ammoniation is effective in improving dry matter digestibility and voluntary feed intake, and has the added benefit of increasing the crude protein content of the treated crop residue (Han and Garrett, 1986). Garrett et al. (1974) found that lambs consumed more feed and had higher gains on diets in which untreated rice straw had been replaced with ammoniated rice straw. Untreated rice straw had a digestible energy value of about 51% that of alfalfa hay while ammoniated rice straw had a digestible energy concentration of about 70% that of alfalfa hay. I. K. Han (personal communication) found that steers gained consistently faster

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Received January 13, 1988
Accepted March 23, 1988

when they were fed diets containing ammoniated rice straw instead of untreated rice straw.

Little information is available concerning the effect of ammonia treatment of crop residues on carcass and meat quality. Therefore, the objectives of the present investigation were to examine the effects of substituting high quality grain or alfalfa-hay finishing rations with untreated rice straw (URS) or anhydrous ammonia treated rice-straw (ARS) on carcass traits, carcass composition and meat palatability of steers.

## Materials and Methods

Ninety feeder steers, predominantly Herefords, weighing approximately 280 kg were obtained from the University of California at Davis (UCD) Sierra Field Station. Upon arrival at the UCD feedlot, the steers were implanted with Synovex-S and were assigned at random in a comparative slaughter feeding experiment to nine diets: basal (high concentrate); 25 or 50% of untreated rice straw (URS) or ammoniated (plastic covered bales, 4.6% $NH_3$ by weight) rice straw (ARS) proportionately replacing part of the basal; a 50:50 mixture of URS/alfalfa or ARS/alfalfa replacing a proportion of the basal at 25 and 50% (table 1). All diets were formulated to contain about 12% protein and any necessary vitamins and minerals. Each nutritional regimen consisted of 10 individually fed steers (constant access to feed and water). Half the experimental animals from each treatment were slaughtered after 154 days and half after 161 days of feeding.

At the end of the feeding period, the cattle were transported to a commercial packing plant and slaughtered. Carcasses were chilled in a 4°C cooler and the temperature drop in the center of the loin eye muscle was monitored at 2 h intervals. At 24 h postmortem, a USDA meat grader assigned USDA quality grade factors (USDA,

TABLE 1. COMPOSITION OF DIETS

| Ingredients | Basal | Rice Straw | | | | Rice Straw/Alfalfa | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Control | | Ammoniated | | Control | | Ammoniated | |
| | | 25% | 50% | 25% | 50% | 25% | 50% | 25% | 50% |
| **Ingredients, %** | | | | | | | | | |
| Untreated rice straw (URS) | 5.0 | 28.7 | 52.4 | – | – | 16.3 | 27.5 | – | – |
| Ammoniated rice straw (ARS) | – | – | – | 28.7 | 52.4 | – | – | 16.3 | 27.5 |
| Alfalfa | – | – | – | – | | 12.5 | 25.0 | 12.5 | 25.0 |
| Corn | 73.0 | 53.1 | 33.6 | 53.6 | 34.6 | 54.1 | 35.8 | 54.2 | 36.3 |
| Soybean meal | 10.0 | 7.4 | 5.0 | 7.4 | 4.9 | 7.5 | 5.0 | 7.6 | 4.8 |
| Molasses | 8.0 | 6.0 | 4.0 | 6.0 | 4.0 | 6.0 | 4.0 | 6.0 | 4.0 |
| Fat | 2.4 | 1.9 | 1.4 | 1.9 | 1.4 | 1.9 | 1.5 | 1.7 | 1.2 |
| Dicalcium Phosphate | .5 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | .7 | 1.0 | .7 |
| Oyster shell | .6 | .6 | .6 | .6 | .6 | .2 | – | .2 | – |
| Trace mineral salt[a] | .5 | .5 | .5 | .5 | .5 | .5 | .5 | .5 | .5 |
| Urea | – | .8 | 1.5 | .3 | .6 | – | – | – | – |
| Vitamin A premix[b] | + | + | + | + | + | + | + | + | + |
| **Nutrient composition** | | | | | | | | | |
| Digestible dry matter, % | 77.9 | 65.2 | 59.3 | 68.1 | 60.1 | 68.9 | 63.7 | 68.3 | 65.5 |
| Crude protein, % | 12.4 | 12.3 | 12.1 | 12.2 | 12.1 | 12.2 | 12.1 | 12.6 | 13.0 |
| ME, Mcal/kg | 2.8 | 2.3 | 1.9 | 2.4 | 2.0 | 2.4 | 2.2 | 2.4 | 2.3 |

[a]Contains: NaCl, 95%; Zn, 0.35%; Mn, 0.28%; Fe, 0.17%; Cu, 0.035%; Co, 0.007%; I, 0.007%.
[b]62.4 g of vitamin A premix was added to 100 kg of experimental diet.

1975) and grades to each carcass. At the same time, rib-eye area and fat thickness were measured at the 12th rib.

The right side of each carcass was shipped via refrigerated truck to the UCD meat laboratory. Final body composition of experimental steers was determined from carcass density as described by Garrett and Hinman (1969).

Two 2.54 cm thick steaks were cut from the primal rib starting from the 12th rib. The steaks were placed in a plastic bag, vacuum packaged, transferred to a holding cooler (4°C) and aged for 7 d. After aging, the steaks were frozen and stored at −20°C for subsequent palatability determinations. Each pair of frozen steaks were removed from the freezer and thawed for 24 h in a cooler prior to cooking. Each steak was then placed 12 cm from the heating coil in an electric oven and oven broiled to a final internal temperature of 70°C as monitored by a metal thermometer inserted in the geometric center of each steak. During cooking the steaks were turned every 6 minutes to insure even distribution of heat. Samples from the cooked 11th rib steak were served, while warm, to a trained 6-member sensory panel for the evaluation of palatability (AMSA, 1975). Panelists independently rated the samples using an 8-point descriptive scale (8 = extremely tender, no detectable connective tissue, extremely juicy, extremely intense flavor, and extremely acceptable overall palatability; 1 = extremely tough, abundant connective tissue, extremely dry, extremely bland, and unacceptable overall palatability). The average panel score for each sensory attribute was used in the statistical analysis.

The 12th rib steak was allowed to cool to room temperature (25°C) before three 2 cm core samples were extracted from the central, medial and lateral locations, parallel to the longitudinal orientation of the muscle fibers, for Warner-Bratzler (WB) shear force measurements. One shear was obtained from each core sample and the overall WB value was an average of the three values. After removing the core samples, the remaining central portion of each steak was coarsely ground. A 20 g sample of ground meat was used for Lee-Kramer (LK) shear force measurements as described by Lee (1983). Shear force measurements (WB and LK) were conducted on an Instron machine.

Data were analyzed using the analysis of variance and Duncan's multiple range test (Steel and Torrie, 1960).

## Results and Discussion

Carcass characteristics of beef fed nine dietary

TABLE 2. CARCASS MEASUREMENTS AND QUALITY TRAITS BY NUTRITIONAL REGIMEN

| | | Rice Straw | | | | Rice Straw/Alfalfa | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Control | | Ammoniated | | Control | | Ammoniated | | |
| Item | Basal | 25% | 50% | 25% | 50% | 25% | 50% | 25% | 50% | SE |
| Carcass weight, kg | 308.2$^{c}$ | 289.3$^{c}$ | 243.3$^{d}$ | 296.8$^{c}$ | 265.1$^{e}$ | 303.8$^{c}$ | 283.9$^{ce}$ | 293.7$^{c}$ | 280.1$^{ce}$ | 3.7 |
| Dressing percentage, % | 62.1$^{cd}$ | 61.4$^{ce}$ | 58.4$^{g}$ | 62.7$^{d}$ | 60.2$^{f}$ | 63.0$^{g}$ | 60.7$^{ef}$ | 62.8$^{d}$ | 61.3$^{ce}$ | .2 |
| Maturity | A | A | A | A | A | A | A | A | A | |
| Marbling score$^{a}$ | 4.8$^{c}$ | 4.6$^{c}$ | 3.5$^{d}$ | 4.5$^{c}$ | 3.7$^{cd}$ | 4.5$^{c}$ | 4.6$^{c}$ | 4.2$^{c}$ | 4.3$^{c}$ | .1 |
| Quality grade$^{b}$ | 11.2$^{c}$ | 10.9$^{c}$ | 8.4$^{e}$ | 10.9$^{c}$ | 9.0$^{de}$ | 10.8$^{c}$ | 11.2$^{c}$ | 10.4$^{cd}$ | 10.3$^{cd}$ | .2 |
| Backfat thickness, cm | 1.4$^{c}$ | 1.2$^{c}$ | .5$^{d}$ | 1.3$^{c}$ | .8$^{e}$ | 1.2$^{c}$ | 1.1$^{c}$ | 1.2$^{c}$ | 1.1$^{c}$ | .1 |
| Kidney, heart, pelvic fat, % | 2.6$^{ce}$ | 2.5$^{cde}$ | 1.9$^{f}$ | 2.6$^{ce}$ | 2.1$^{df}$ | 2.9$^{e}$ | 2.6$^{ce}$ | 2.7$^{ce}$ | 2.4$^{cd}$ | .1 |
| Rib eye area, cm$^{2}$ | 76.8$^{c}$ | 74.6$^{c}$ | 66.0$^{d}$ | 75.9$^{c}$ | 70.7$^{cd}$ | 73.3$^{c}$ | 72.4$^{c}$ | 74.5$^{c}$ | 72.4$^{c}$ | .7 |
| Yield grade | 3.2$^{c}$ | 2.9$^{cd}$ | 2.1$^{e}$ | 3.0$^{c}$ | 2.4$^{de}$ | 3.2$^{c}$ | 2.9$^{cd}$ | 3.0$^{c}$ | 2.8$^{cd}$ | .1 |

[a] Sm = 5.0, Sm$^{-}$ 4.7, Sl$^{+}$ = 4.3, Sl = 4, Sl$^{-}$ = 3.7, Tr$^{+}$ = 3.3, Tr = 3.0, Tr$^{-}$ = 2.7.

[b] Avg Choice = 13, low choice = 12, high Good = 11, avg Good = 10, low Good = 9, high Standard = 8, avg Standard = 7, low Standard = 6.

[c, d, e, f, g] Means with different superscripts in the same row differ significantly ($P < .05$).

regimens are presented in table 2. The 50% URS group showed lower ($p < .05$) values in all the carcass traits, followed by 50% ARS, 50% rice straw/alfalfa, and 25% rice straw alone or rice straw/alfalfa mixture. Ammoniation of rice straw increased final carcass weight, dressing %, backfat thickness, kidney, pelvic and heart (KPH) fat, rib eye area, quality and yield grades as compared to untreated rice straw. No statistical differences were found among basal diet and 25% ARS or URS groups, indicating that 25% substitution with rice straw did not significantly affect carcass traits. When alfalfa was included in the diet, all carcass traits were improved compared to rice straw alone, particularly at the 50% substitution level. No statistical differences were found among the basal diet group and 50% URS-alfalfa or 50% ARS-alfalfa groups for any carcass traits except dressing %.

Effects of dietary energy on carcass traits in our study are in agreement with those of previous studies (Moody, 1976; Bowling et al., 1977; Aberle et al., 1981) which reported a higher rate of gain, higher dressing percentage, larger rib eye area, more carcass fat, higher quality grade and lower cutability for the high energy or high grain-fed cattle.

Final body composition of steers on the different nutritional regimens is summarized in table 3. As expected, the 50% ARS and 50% URS groups had less ($p < .05$) body fat and higher water and protein contents than cattle on the other diets. No differences were found among the remaining treatment groups in body composition. Because

TABLE 3. FINAL BODY COMPOSITION OF STEERS BY NUTRITIONAL REGIMEN

| | | Rice Straw | | | | Rice Straw/Alfalfa | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Control | | Ammoniated | | Control | | Ammoniated | | |
| Item | Basal | 25% | 50% | 25% | 50% | 25% | 50% | 25% | 50% | SE |
| Water, % | 51.9$^{a}$ | 53.8$^{a}$ | 58.8$^{b}$ | 52.5$^{a}$ | 57.6$^{b}$ | 53.0$^{a}$ | 53.8$^{a}$ | 53.4$^{a}$ | 54.1$^{a}$ | .4 |
| Fat, % | 28.8$^{a}$ | 26.2$^{a}$ | 19.7$^{b}$ | 27.9$^{a}$ | 21.3$^{b}$ | 27.3$^{a}$ | 26.3$^{a}$ | 26.7$^{a}$ | 25.8 | .5 |
| Protein, % | 15.8$^{a}$ | 16.3$^{a}$ | 17.5$^{b}$ | 15.9$^{a}$ | 17.2$^{b}$ | 16.0$^{a}$ | 16.2$^{a}$ | 16.2$^{a}$ | 16.3$^{a}$ | .1 |
| Energy, Mcal/kg | 3.6$^{a}$ | 3.4$^{a}$ | 2.8 | 3.5$^{a}$ | 2.9$^{b}$ | 3.5$^{a}$ | 3.4$^{a}$ | 3.4$^{a}$ | 3.3$^{a}$ | .1 |

[a,b]Means in the same row with different superscripts differ significantly ($P < .05$).

TABLE 4. PALATABILITY ATTRIBUTES BY NUTRITIONAL REGIMEN

| | | Rice Straw | | | | Rice Straw/Alfalfa | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Control | | Ammoniated | | Control | | Ammoniated | | |
| Item | Basal | 25% | 50% | 25% | 50% | 25% | 50% | 25% | 50% | SE |
| WB shear, kg | 6.5$^{cd}$ | 6.5$^{cd}$ | 6.9$^{cd}$ | 7.1$^{c}$ | 7.0$^{c}$ | 6.9$^{c}$ | 6.7$^{cd}$ | 6.6$^{cd}$ | 6.1$^{d}$ | .1 |
| L-K shear, kg[a] | 105.5$^{cd}$ | 109.2$^{cd}$ | 113.6$^{cd}$ | 114.4$^{cd}$ | 111.7$^{cd}$ | 109.4$^{cd}$ | 111.7$^{c}$ | 117.0$^{d}$ | 97.7 | 2.5 |
| Tenderness[b] | 4.8 | 5.3 | 5.0 | 4.7 | 5.0 | 4.8 | 5.0 | 4.7 | 5.5 | .2 |
| Connective[b] tissue amount | 5.0$^{cd}$ | 5.1$^{cd}$ | 5.3$^{cd}$ | 4.9$^{cd}$ | 5.0$^{cd}$ | 4.9$^{cd}$ | 5.0$^{cd}$ | 4.8$^{c}$ | 5.5$^{d}$ | .1 |
| Juiciness[b] | 4.8 | 5.1 | 5.1 | 4.7 | 5.1 | 4.9 | 5.1 | 4.9 | 5.0 | .1 |
| Flavor intensity[b] | 5.1 | 5.1 | 4.9 | 5.0 | 4.8 | 4.8 | 4.9 | 4.9 | 4.9 | .1 |
| Overall palatability[b] | 4.5 | 5.1 | 4.6 | 4.3 | 4.8 | 4.5 | 4.8 | 4.5 | 5.3 | .2 |

[a]Lee-Kramer shear expressed as kg force/20 g meat sample.

[b]8 = extremely tender, 1 = extremely tough; 8 = none, 1 = abundant; 8 = extremely juicy, 1 = extremely dry; 8 = extremely intense, 1 = extremely bland; 8 = extremely acceptable, 1 = unacceptable.

[c, d]Means in the same row with different superscripts differ significantly ($P < .05$).

of low fat content, energy content per gram of body weight was lower ($p < .05$) in 50% URS and 50% ARS treatment groups. No differences were found in energy content among the remaining treatment groups.

Beef from cattle finished on high energy diets is generally more tender, more desirable in flavor and more satisfactory in overall palatability than beef from cattle finished on low energy diets or pasture (Bowling et al., 1977; Harrison et al., 1978; Aberle et al., 1981). In our study, little difference was found in shear value, panel tenderness and residual connective tissue among the treatment groups (table 4). All were marginal in tenderness – only "slightly tender".

The decline of carcass temperature as monitored during conventional chilling in a commercial packing plant by a metal thermometer inserted in the center of the *longissimus* muscle was very gradual with a drop of 2.5 °C/h during the first 5 h of chilling (33°C at 3h and 27°C at 5h). This delayed chilling could explain why meat from the lower fat carcasses (50% URS and ARS groups) was comparable in tenderness to other carcasses. Bowling et al. (1977) also reported that high-temperature chilled, forage-finished beef was not different from grain finished beef in ratings of muscle fiber tenderness or amount of organoleptically-detectable connective tissue.

No differences were found in juiciness, flavor intensity and overall palatability among the treatment groups. This indicates that 25 to 50% of rice straw in the diet did not adversely affect meat palatability when carcases were chilled slowly. The USDA marbling score of 50% URS fed cattle was 3.5 (between trace$^+$ and slight$^-$) compared to 4.8 (sm$^-$) of cattle fed the basal diet (table 3). Thus, one unit difference in marbling score did not cause any difference in flavor perceived by the panel. Since even the 50% roughage groups consumed substantial amounts of concentrates and carcasses were chilled slowly, it is not surprising to find acceptable beef produced from all treatments.

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