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Effects of graded levels of supplemental feather meal on performance and carcass characteristics of finishing beef cattle

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Introduction

The NRC (1996) changed from the factorial protein system to a metabolizable protein (MP) system for beef cattle. In the MP system, dietary crude protein (CP) is subdivided into degraded intake protein (DIP) and undegraded intake protein (UIP). The quantity of microbial protein produced in the rumen dictates DIP requirements. Steam-flaked corn is the predominant grain used in the diets of finishing beef cattle in Great Plains. Because steam-flaked corn is rapidly and extensively fermented in the rumen, microbial protein production is high. Therefore, the NRC (1996) requirements for DIP are increased with steam-flaked corn diets compared with diets based on less extensively processed grain. Feather meal is a protein source that has a relatively low content of DIP and a relatively high content of UIP. As a result, most feedlot nutritionists who use the MP system would discount the value of feather meal in steam-flaked corn diets. Our recent research (Gleghorn, 2003) suggests that DIP requirements with steam-flaked corn diets may not be as high as suggested by the NRC (1996) MP system. Hence, discrimination against high UIP sources like feather meal might not be justified. Data suggest that feather meal can increase performance by growing cattle (Klemesrud et al., 2000); however, data are lacking evaluating the use of feather meal as a protein source for

feedlot cattle fed steam-flaked corn-based finishing diets.

Experimental Procedures

Cattle. Two hundred sixteen beef steers of primarily British (Angus, Hereford, and Angus x Hereford), British x Charolais, and British x Continental breeding were purchased through various sources (169 steers through Prairie Livestock, Inc., Perryville, MO; 10 steers from Floydada Livestock Sales, Inc., Floydada TX; and 37 steers from Lubbock Stockyards, Inc., Lubbock, TX) and transported to the Texas Tech University Burnett Center (average BW = 590 lb). Cattle were processed after arrival to the Burnett Center which included the following: 1) individual body weight (BW) measurement; 2) uniquely numbered ear tag in the left ear; 3) vaccination with Vision 8 Somnus with SPUR (Intervet; Millsboro, DE); 4) vaccination with Pyramid 9 (Fort Dodge Animal Health, Overland Park, KS); and 5) treatment down the back line with Cydectin (Fort Dodge Animal Health). After processing, cattle were maintained in soil-surfaced pens until they were assigned to treatments. During this time, the diet was stepped-up (each step was approximately a 10% increase in concentrate level) to a final level of 90% concentrate.

Experimental Design. The four dietary treatments were arranged in a randomized

complete block design. Pen was the experimental unit (five steers per pen), and there was one pen (9.5 x 18.3 ft, with 8 ft of linear bunk space) for each treatment in each of the nine blocks. The four dietary treatments were as follows:

100U – Ratio of urea:feather meal (N basis) in the supplemental CP = 100:0;

75U – Ratio of urea:feather meal (N basis) in the supplemental CP = 75:25;

50U – Ratio of urea:feather meal (N basis) in the supplemental CP = 50:50;

25U – Ratio of urea:feather meal (N basis) in the supplemental CP = 25:75.

Only 180 steers were used in the experiment, but to facilitate routine care and husbandry of the entire group of cattle that had been purchased and were available for use in the study (210 steers), a decision was made to randomly intersperse one pen of extra cattle among the blocks of treatment cattle. Cattle used in the experiment were selected on the basis of uniformity of frame and BW and blocked into the nine weight blocks. At the time of sorting into blocks, each steer was implanted in the right ear with Revalor IS (Intervet). After sorting into blocks, the cattle in each block were taken through the working facilities again and sorted into the pens within each block. Cattle were then moved into their assigned pens in the Burnett Center, where they continued to receive the same 90% concentrate diet that they received previously. Three days later, all cattle were weighed individually, and the experiment was initiated.

Experimental Diets. Ingredient composition of the diets fed during the experiment is shown in Table 1. These data reflect adjustments for the average DM matter content of feed ingredients for the

period during which a given diet was fed. All diets contained the same intermediate premix (Table 2), which supplied various minerals and vitamins, Rumensin (30 g/ton, DM basis), and Tylan (8 g/ton, DM basis).

Management, Feeding, and Weighing Procedures. The four treatment diets were mixed in a 45-cubic foot capacity Marion paddle mixer. Once the total amount of feed for a given treatment was mixed, the mixed batch was released from the mixer and delivered by a drag-chain conveyer to a Rotomix 84-8 delivery system. Feed was delivered to the treatments pens (\pm 1 lb) by use of the load cells and indicator on the Rotomix 84-8 unit.

Dry matter determinations on ingredients used in the experimental diets were made every 2 wk during the experiment. In addition, samples of mixed feed delivered to feed bunks were taken weekly throughout the experiment. Samples of feed taken from the bunk were composited for each interval in which cattle were weighed (typically 28-d intervals) during the experiment. Composited samples were ground to pass a 2-mm screen in a Wiley mill and analyzed for DM, ash, CP, and ADF (AOAC, 1990). Values for Ca and P were calculated based on ingredient composition of the diets (NRC, 1996; Table 3).

Scales used to obtain animal weights were calibrated with 1,000 lb of certified (Texas Department of Agriculture) weights just before use. After 28, 84, 56, and 112 d on feed, cattle were weighed on a pen basis using a platform scale (\pm 5 lb). On d 56, immediately following the pen BW measurement, each steer was restrained in a hydraulic squeeze chute and implanted with Revalor S (Intervet). On d 112, it was visually estimated that steers in Blocks 8

and 9 would have sufficient finish to grade USDA Choice in approximately 2 wk; therefore, these steers were weighed individually (scale accuracy ± 1 lb) on d 126 and shipped to the Excel Corp. slaughter facility in Plainview, TX. On d 140, remaining pens were weighed (pen basis) for their scheduled weigh day. Cattle in Blocks 6 and 7 were weighed individually on d 144 and shipped to the slaughter facility, whereas cattle in Blocks 3, 4, and 5 were weighed individually on d 158 and shipped to the slaughter. Finally, cattle in Blocks 1 and 2 were weighed individually on d 173 and shipped to the Excel facility in Plainview.

Carcass Evaluation. Carcass measurements included hot carcass weight, longissimus muscle area, marbling score, percentage of kidney, pelvic, and heart (KPH) fat, fat thickness measured between the 12th and 13th ribs, yield grade, quality grade, and liver abscess score. Liver abscess score was recorded on a scale of 0 to 6, with 0 = no abscesses, 1 = A-, 2 = A, 3 = A+, 4 = telangiectasis, 5 = fluke damage, and 6 = fecal contamination that occurred at slaughter.

Statistical Analyses. All performance data were analyzed with pen as the experimental unit. A randomized complete block design was employed, and computations were made with the Mixed procedure of SAS (SAS Inst. Inc., Cary, NC). Pen means for ADG and average daily DMI were included in the data file, and gain:feed ratio was computed as the quotient of daily DMI divided by daily gain. Carcass-adjusted ADG and carcass adjusted gain:feed were calculated from carcass-adjusted BW, which was derived by dividing the hot carcass weight by the average dressing percent of all the cattle.

The effect of treatment was included in the model for pen-based data, with block as a random effect. Carcass data were entered on an individual animal basis and analyzed with a model that included effects of treatment, block, and block x treatment. Block and block x treatment were specified as the random terms, with block x treatment used to test treatment effects. Residual mean square in this model for carcass data (not used for testing) included individual animal variation. Orthogonal contrasts were computed and used to evaluate the treatment response surface (linear, quadratic, and cubic effects). When the overall F test was significant ($P < 0.10$), the PDIFF option also was used to separate the least squares means.

Results and Discussion

Cattle Performance. Performance results are presented in Table 4. No differences were noted for final BW or carcass-adjusted final BW. As indicated previously, carcass-adjusted final BW was calculated by dividing the hot carcass weight (HCW) by the average dressing percent for all treatments. No differences ($P > 0.10$) were noted with regard to ADG on d 0 to 28, 0 to 56, 0 to 84, or for the overall feeding period (average of 151 d on feed); however, a quadratic response ($P < 0.07$) was detected for d 0 to 112 ADG, with cattle on the 25U treatment having the lowest ADG. When overall ADG was calculated using carcass-adjusted final BW, a linear decrease ($P < 0.06$) was observed in carcass-adjusted ADG. When carcass-adjusted ADG means were separated by the PDIFF option, it was noted that cattle on the 25U treatment gained less ($P < 0.01$) than those on the other three treatments, which did not differ from each other. It is unclear why cattle fed the highest concentration of feather meal did

not perform as well as their counterparts in the other treatments. Loest et al. (2002) attempted to increase digestibility of feather meal in a steam-flaked corn finishing diet by treating it with peroxide, but they found no differences in cattle performance between treated and untreated feather meal. Although not significant, steers receiving the highest level of feather meal (25U) in the present study had numerically lower overall DMI (Table 5). Perhaps the palatability of the diets was adversely affected by the highest level of feather meal. The lower DMI likely resulted in the lower carcass-adjusted ADG observed in the present study with the 25U treatment. When van Heugten and van Kempen (2002) fed hydrolyzed feather meal to swine, a decrease in DMI was observed when the pigs were fed up to 10% feather meal in the diet, but this decrease did not affect ADG. Klemesrud et al. (2000) supplemented the diets of growing cattle with either 1 or 2% feather meal and observed an increase in ADG, perhaps as a result of the high sulfur amino acids contained in feather meal. The cattle in the Klemesrud et al. (2000) study were lighter in BW than the cattle used in the present study, and they may have had higher proportional requirements for protein. Moreover, the diets fed in the present study were much higher in grain than those used by Klemesrud et al. (2000).

As a result of the offsetting effects of a decrease in both DMI and ADG as feather meal level increased, no differences ($P > 0.10$) in gain:feed ratio (live weight or carcass-adjusted weight basis) were observed at any time during the study (Table 6). Similarly, Loest et al. (2002) detected no differences between treated and untreated feather meal for feed efficiency of finishing cattle. Calculated dietary NEM and NEg concentrations (DM basis) based on animal

performance (NRC, 1996) were 2.40 and 1.70 Mcal/kg; 2.36 and 1.66 Mcal/kg; 2.38 and 1.68 Mcal/kg; and 2.37 and 1.67 Mcal/kg for the 100U, 75U, 50U, and 25U diets, respectively.

Carcass Measurements. A trend ($P = 0.15$) for a linear decrease in HCW (Table 7) was observed as the proportion of urea in the supplemental CP decreased, with cattle receiving the highest level of feather meal (25U) having lighter carcasses. This result reflects the decreased carcass-adjusted ADG observed during the feeding period for the 25U treatment. No differences were observed in USDA yield grade among the treatments. Loest et al. (2002) also observed no differences in yield grade in cattle fed either peroxide-treated or untreated feather meal. A linear decrease ($P < 0.01$) was noted for dressing percent, and pair-wise treatment comparisons indicated that cattle fed highest level of feather meal (25U) had a lower dressing percent ($P < 0.10$) than those fed the 100U and 75U diets, with an intermediate value for cattle fed the 50U diet. It is unclear why this difference was observed. Perhaps the greater undegraded protein associated with the feather meal might have resulted in greater water retention in the gut. Abe et al. (1999) fed a concentrate diet to growing Holstein bull calves and reported increased fecal moisture compared with cattle fed hay alone. Similarly, fishmeal increased fecal moisture in cats compared with corn gluten meal (Funaba et al., 2001). No differences were observed ($P < 0.10$) in percentage of carcasses grading USDA Choice, marbling score, backfat measured at the 12th rib, or longissimus muscle area. Loest et al. (2002) also observed no effects of feeding feather meal on carcass characteristics of finishing cattle.

Implications

Addition of feather meal to supply 25 or 50% of the supplemental crude protein did not significantly affect feedlot performance or carcass characteristics relative to a diet in which the supplemental CP was supplied by 100% urea. However, cattle fed a steam-flaked corn-based diet in which feather meal supplied 75% of the supplemental CP had lower carcass-adjusted daily gain and a lower dressing percent than cattle in the other treatment groups. No differences were noted among treatments for feed efficiency or for most of the carcass characteristics measured. Based on our results, feather meal can replace for up to half the nitrogen supplied by urea in finishing diets without statistically significant effects on performance by beef cattle fed steam-flaked corn-based diets. Moreover, feather meal can replace 25% of the nitrogen supplied by urea with almost no change in performance by cattle fed a steam-flaked corn-based finishing diet.

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Table 1. Ingredient composition (% DM basis) of concentrate diets

| Ingredient | Proportion of urea in supplemental CP ^a | | | |
|---------------------|--|-------|-------|-------|
| | 100U | 75U | 50U | 25U |
| Steam-flaked corn | 78.95 | 78.09 | 77.11 | 76.35 |
| Alfalfa hay | 9.88 | 9.79 | 9.89 | 9.77 |
| Feather meal | 0.00 | 1.19 | 2.46 | 3.74 |
| Urea | 1.31 | 1.01 | 0.68 | 0.35 |
| Molasses | 4.13 | 4.23 | 4.22 | 4.22 |
| Fat (yellow grease) | 3.03 | 3.04 | 3.03 | 3.03 |
| Dicalcium phosphate | 0.11 | 0.11 | 0.11 | 0.00 |
| Premix ^b | 2.52 | 2.54 | 2.50 | 2.55 |

^a100U = 100% urea:0% feather meal; 75U = 75% urea:25% feather meal; 50U = 50% urea:50% feather meal; 25U = 25% urea:75% feather meal (% N basis).

^bComposition of the premix is shown in Table 2.

Table 2. Composition of the premix used in experimental diets

| Ingredient | %, DM basis |
|--------------------------------------|-------------|
| Ground corn | 25.6313 |
| Kemin Endox (antioxidant) | 0.5456 |
| Limestone | 40.7567 |
| Dicalcium phosphate | 1.0272 |
| Potassium chloride | 7.7515 |
| Magnesium oxide | 3.4642 |
| Ammonium sulfate | 6.4519 |
| Salt | 11.6157 |
| Cobalt carbonate | 0.0017 |
| Copper sulfate | 0.1550 |
| Iron sulfate | 0.1298 |
| EDDI | 0.0024 |
| Manganese oxide | 0.2585 |
| Selenium premix, 0.2% Se | 0.0968 |
| Zinc sulfate | 0.8215 |
| Vitamin A, 650,000 IU/g ^a | 0.0124 |
| Vitamin E, 500 IU/g ^a | 0.1249 |
| Rumensin, 80 mg/lb ^a | 0.6872 |
| Tylan, 40 mg/lb ^a | 0.4657 |

^aConcentrations noted by ingredients are on a 90% DM basis.

Table 3. Chemical composition of the experimental diets

| Item | Proportion of urea in supplemental CP ^b | | | |
|--------------------|--|-------|-------|-------|
| | 100U | 75U | 50U | 25U |
| Dry matter, % | 81.04 | 80.74 | 81.05 | 81.24 |
| Crude protein, % | 12.36 | 12.69 | 12.43 | 12.08 |
| ADF, % | 7.11 | 7.26 | 7.56 | 8.10 |
| Ash, % | 6.23 | 6.06 | 5.85 | 6.46 |
| Ca, % ^c | 0.65 | 0.66 | 0.68 | 0.67 |
| P, % ^c | 0.30 | 0.31 | 0.31 | 0.30 |

^aAll values except Dry matter, % are expressed on a DM basis.

^b100U = 100% urea:0% feather meal; 75U = 75% urea:25% feather meal; 50U = 50% urea:50% feather mea; 25U = 25% urea:75% feather meal (% N basis).

^cCalculated values based on ingredient composition of the diets (NRC, 1996).

Table 4. Effect of proportions of urea and feather meal in the supplemental CP source on body weight and average daily gain

| Item | Proportion of urea in supplemental CP ^a | | | | SEM | Contrast ^b | |
|--|--|-------------------|-------------------|-------------------|-------|-----------------------|------|
| | 100U | 75U | 50U | 25U | | L | Q |
| Initial BW, lb | 748.3 | 753.0 | 751.1 | 759.7 | 24.67 | - | - |
| Final BW, lb | 1,276.0 | 1,280.2 | 1,280.0 | 1,265.0 | 20.35 | 0.63 | 0.54 |
| Adj. final BW, lb | 1,286.6 | 1,283.4 | 1,277.1 | 1,253.9 | 21.58 | 0.15 | 0.53 |
| ADG, lb/d | | | | | | | |
| d 0 to 28 | 3.65 | 3.67 | 3.47 | 3.46 | 0.205 | 0.34 | 0.23 |
| d 0 to 56 | 3.51 | 3.59 | 3.56 | 3.34 | 0.156 | 0.40 | 0.32 |
| d 0 to 84 | 3.53 | 3.71 | 3.59 | 3.38 | 0.125 | 0.21 | 0.06 |
| d 0 to 112 | 3.50 | 3.64 | 3.54 | 3.35 | 0.102 | 0.16 | 0.06 |
| d 0 to end ^c | 3.49 | 3.51 | 3.50 | 3.37 | 0.100 | 0.33 | 0.43 |
| Carcass-adjusted ADG, d 0 to end ^d | 3.58 ^e | 3.53 ^e | 3.49 ^e | 3.30 ^f | 0.111 | 0.05 | 0.44 |

^a100U = 100% urea:0% feather meal; 75U = 75% urea:25% feather meal; 50U = 50% urea:50% feather meal; 25U = 25% urea:75% feather meal (% N basis).

^bL = linear and Q = quadratic effects of CP source (100U to 25U).

^cCattle were fed an average of 151 d.

^dAdjusted final BW calculated using average dressing percent (62.08%) across all treatments.

^{e,f}Within a row, means that do not have a common superscript differ (P < 0.10).

Table 5. Effect of proportions of urea and feather meal in the supplemental CP source on dry matter intake

| | Proportion of urea in supplemental CP ^a | | | | SEM | Contrast ^b | |
|---------------------------|--|-------|-------|-------|-------|-----------------------|------|
| | 100U | 75U | 50U | 25U | | L | Q |
| DM intake, lb/steer daily | | | | | | | |
| d 0 to 28 | 15.53 | 15.32 | 14.47 | 14.73 | 0.697 | 0.07 | 0.56 |
| d 0 to 56 | 15.91 | 15.98 | 15.33 | 15.22 | 0.683 | 0.13 | 0.82 |
| d 0 to 84 | 16.23 | 16.27 | 15.64 | 15.40 | 0.666 | 0.07 | 0.70 |
| d 0 to 112 | 16.54 | 16.67 | 16.17 | 15.74 | 0.647 | 0.10 | 0.47 |
| d 0 to end ^c | 16.93 | 17.16 | 16.86 | 16.38 | 0.551 | 0.28 | 0.38 |

^a100U = 100% urea:0% feather meal; 75U = 75% urea:25% feather meal; 50U = 50% urea:50% feather meal; 25U = 25% urea:75% feather meal (% N basis).

^bL = linear and Q = quadratic effects of CP source (100U to 25U).

^cCattle were fed for an average of 151 d.

Table 6. Effect of proportions of urea and feather meal in the supplemental CP source on gain:feed ratio

| | Proportion of urea in supplemental CP ^a | | | | SEM | Contrast ^b | |
|-------------------------|--|-------|-------|-------|-------|-----------------------|------|
| | 100U | 75U | 50U | 25U | | L | Q |
| Gain:feed | | | | | | | |
| d 0 to 28 | 0.236 | 0.240 | 0.241 | 0.235 | 0.010 | 0.87 | 0.56 |
| d 0 to 56 | 0.222 | 0.225 | 0.234 | 0.220 | 0.007 | 0.83 | 0.17 |
| d 0 to 84 | 0.219 | 0.229 | 0.225 | 0.221 | 0.005 | 0.89 | 0.07 |
| d 0 to 112 | 0.212 | 0.219 | 0.230 | 0.221 | 0.005 | 0.60 | 0.01 |
| d 0 to end ^c | 0.208 | 0.205 | 0.208 | 0.206 | 0.004 | 0.89 | 0.89 |
| Carcass-adjusted | | | | | | | |
| d 0 to end ^d | 0.212 | 0.206 | 0.207 | 0.202 | 0.005 | 0.14 | 0.98 |

^a100U = 100% urea:0% feather meal; 75U = 75% urea:25% feather meal; 50U = 50% urea:50% feather meal; 25U = 25% urea:75% feather meal (% N basis).

^bL = linear and Q = quadratic effects of CP source (100U to 25U).

^cCattle were fed for an average of 151 d.

^dAdjusted final BW was calculated using average dressing percent (62.08%) across all treatments.

Table 7. Effect of proportions of urea and feather meal in the supplemental CP source on carcass characteristics

| Item | Proportion of urea in supplemental CP ^a | | | | SEM | Contrast ^b | |
|-----------------------------|--|--------------------|---------------------|--------------------|-------|-----------------------|------|
| | 100U | 75U | 50U | 25U | | L | Q |
| HCW ^c | 798.7 | 796.8 | 792.9 | 778.4 | 13.38 | 0.15 | 0.53 |
| Yield grade | 2.85 | 2.80 | 2.76 | 2.69 | 0.164 | 0.37 | 0.97 |
| DP ^d | 62.62 ⁱ | 62.23 ⁱ | 61.94 ^{ij} | 61.52 ^j | 0.256 | <0.01 | 0.96 |
| Choice, % ^e | 78.9 | 81.7 | 78.9 | 70.6 | 5.92 | 0.31 | 0.36 |
| Marbling score ^f | 451 | 458 | 443 | 445 | 14.2 | 0.59 | 0.85 |
| Backfat ^g | 0.49 | 0.49 | 0.51 | 0.47 | 0.038 | 0.81 | 0.47 |
| LMA ^h | 13.55 | 13.68 | 13.90 | 13.67 | 0.289 | 0.57 | 0.45 |

^a100U = 100% urea:0% feather meal; 75U = 75% urea:25% feather meal; 50U = 50% urea:50% feather meal; 25U = 25% urea:75% feather meal (% N basis).

^bL = linear and Q = quadratic effects of CP source (100U to 25U).

^cHot carcass weight.

^dDressing percent = (HCW/final live weight) x 100.

^ePercentage of carcasses grading USDA Choice or better within a treatment.

^fMarbling score: 300 = Slight⁰⁰; 400 = Small⁰⁰; 500 = Modest⁰⁰.

^gBackfat measured at the 12th rib.

^hLongissimus muscle area, in².

^{ij}Within a row, means that do not have a common superscript differ (P < 0.10).