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Effects of high-oil corn and mill-run corn plus added fat on performance and carcass characteristics of finishing beef steers

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Introduction

Recent advances in genetic modification of plants have resulted in the potential to markedly alter the nutrient content of cereal grains. One example that has arisen from traditional plant breeding methods is the development of high-oil varieties of corn. The effect, however, of such changes in the nutrient content of corn and other cereal grains on their feeding value for beef cattle is largely unknown. Our objective was to determine whether feeding steam-flaked high-oil corn affected the performance by finishing beef cattle compared with normal (mill-run) steam-flaked corn.

Experimental Procedures

Cattle. One hundred fifty-six Angus steers were shipped from one ranch near Bowie, TX to the Texas Tech University (TTU) Burnett Center on October 27, 1998. Immediately after arrival, each steer was processed as follows: 1) individual ear tag placed in the left ear; 2) vaccination with Bovishield 4+Lepto (Pfizer Anim. Health); 3) vaccination with Fortress 7 (Pfizer Anim. Health); 4) treatment down the backline with Dectomax Pour-On (Pfizer Anim. Helath); and 5) individual BW measurement. After processing, the cattle were sorted randomly to four dirt-floor pens and fed a 60% concentrate (normal corn) diet at a rate of approximately 10 lb per steer.

Experimental Design. Processing BW data were sorted from least to greatest, and the 36 steers of lightest BW were designated as Extra cattle. The remaining 120 steers were assigned randomly within BW strata by coin toss to either Normal or High Oil treatments. Pens (12 pens per treatment with five steers per pen) were assigned randomly to the following two treatments:

- **Normal –** Diet based on mill-run steam-flaked corn plus added fat;
- **High Oil** – Diet based on high-oil steam-flaked corn.

The experiment was started on November 5, 1998 when an individual BW measurement was obtained, and each steer was implanted with Ralgro (Schering-Plough Anim. Health). All 120 steers were sorted to their assigned pens and fed a 60% concentrate diet with either steam-flaked Normal or High Oil corn.

Experimental Diets. Ingredient composition of the diets fed during the experiment is shown in Table 1. These data reflect adjustments for the average dry matter (DM) content of feed ingredients for the period during which a given diet was fed. Each diet contained the same intermediate premix (Table 2) to supply protein, various minerals and vitamins, Rumensin (30 g/ton, DM basis), and Tylan (8 g/ton, DM basis).

Management, Feeding, and Weighing Procedures. Both 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 amount of feed allotted to each of the 12 pens within treatment was delivered using a Rotomix 84-8 self-propelled delivery system. Mixing and feeding order of treatment diets throughout the experiment was Normal followed by High Oil.

Dry matter determinations on ingredients used in the experimental diets were made every 2 wk throughout the experiment. These ingredient DM values were used to calculate the DM percentage of each dietary ingredient during the experiment. In addition, samples of mixed feed delivered to feed bunks were taken weekly throughout the experiment. These bunk sample DM values were used to compute average DM intake (DMI) by the cattle in each pen (adjusted for any feed refusals). Samples of feed taken from the bunk were composited for each 28-d period of the experiment and further composited across the entire experimental period. Samples were ground to pass a 2-mm screen in a Wiley mill, and overall composites were analyzed for DM, ash, CP, ADF, Ca, and P (AOAC, 1990; Table 3). Composite samples were analyzed for ether extract content after grinding the sample to pass a 1-mm screen by adding approximately 2 g of sample to a 500-mL flask with 100 mL of petroleum ether, shaking the flask for 1 h in an oscillating shaker, filtering the residue, and weighing the dried residue.

Each feed bunk of the 24 pens was evaluated visually at approximately 0700 to 0730 daily. The quantity of feed remaining in each bunk was estimated, and the daily allotment of feed for each pen was recorded. This bunk-reading process was designed to allow for little or no accumulation of unconsumed feed (0 to 1 lb per pen). Pens of cattle that maintained a given level of feed intake for a 3-d period were challenged to consume a higher level (.4 lb/animal challenge). Feed bunks were cleaned, and unconsumed feed was weighed at intervals corresponding to intermediate weigh dates throughout the trial. Dry matter content of feed bunk weighback samples was determined in a forced-air oven by drying for approximately 20 h at 100^{o}C.

After 28, 56, 84, 112, and 140 d on feed, steers in all pens were weighed before the morning feeding. All BW measurements taken during the experiment were obtained using a single-animal scale (C & S Single-Animal Squeeze Chute set on four load cells). The scale was calibrated with 1,000 lb of certified weights (Texas Dept. of Agriculture) on the day before each scheduled weigh day. On d 56, at the time of a regularly scheduled BW measurement, each steer was implanted with Revalor S (Hoechst Roussel Vet). After the 140-d BW measurement, it was estimated that the cattle would have sufficient finish to grade USDA Choice within 2 to 3 wk. Hence, steers were weighed at approximately 0500 on April 19, 1999 and shipped to the Excel Corp. slaughter facility in Plainview, TX. Of the original 120 steers that started the experiment, one steer died, one steer was removed from the experiment, and one steers was withheld from slaughter on d 165 because of a leg injury, resulting in a total of 117 steers being sent to slaughter.

Carcass Evaluation. Personnel of the TTU Meat Laboratory obtained all carcass measurements. Measurements included hot carcass weight, longissimus muscle area, marbling score, percentage of kidney, pelvic, and heart fat (KPH), fat thickness measured between the 12th and 13th ribs, yield grade, and liver abscess score. Liver abscess scores were recorded on a scale of 1 to 7, with 1 = no abscesses, 2 = A-, 3 = A, 4 = A+, 5 = telangiectasis, 6 = distoma (fluke damage), and 7 = fecal contamination that occurred at slaughter. In the present experiment, of the 117 steers sent to the slaughter plant, complete data were obtained on 116 steers for fat thickness, marbling score, KPH, longissimus muscle area, and quality grade. Data for 110 steers were obtained for hot carcass weight, yield grade, and dressing percent.

Statistical Analyses. All data were analyzed with pen as the experimental unit. A completely random design was employed, and computations were made with the GLM procedure of SAS (1987). Pen means for daily gain and average daily DMI were included in the data file, and feed:gain ratio was computed as the quotient of daily DMI divided by daily gain. The effect of treatment was included in the model for pen-based data. Carcass data were entered on an individual animal basis and analyzed with a model that included effects for treatment and pen within treatment. Pen within treatment was specified as the error term for testing treatment effects. Residual mean square in this model for carcass data (not used for testing) would include individual animal variation. Carcass quality grade and liver abscess score data were analyzed by Chi-square procedures (SAS, 1987) using individual animal data.

Results and Discussion

Performance Data. Daily gain, DMI, and feed:gain ratio data are shown in Table 4. Initial BW did not differ between treatments, averaging 634 lb. Final BW after 165 d on feed, however, tended ($P < .08$) to be greater for steers fed Normal corn than for those fed High Oil corn.

Differences in final BW were reflected in differences in daily gain between the treatments over the course of the experiment. Daily gain during d 0 to 28 ($P < .03$), 0 to 84 ($P < .02$), and for the overall 165-d feeding period ($P < .04$) was less by cattle fed High Oil corn than by those fed Normal corn. In addition, gain tended ($P < .10$) to be less with High Oil corn from d 0 to 112. In contrast to these results, daily gain did not differ between cattle fed steam-flaked (26 or 30 lb/bu) Normal or High Oil corn in a recent experiment conducted in Colorado (Soderlund and Owens, 1999). This experiment, however, involved cattle that started on feed at 819 lb and were on feed for 107 d compared with the lighter initial BW and longer feeding period in the present experiment.

Daily DMI (Table 4) did not differ between treatments in any of the cumulative periods of the experiment; however, average DMI for the 165-d feeding period was approximately .5 lb greater by cattle fed High Oil corn than by those fed Normal corn. As a result of differences in daily gain and no differences in feed intake, feed:gain ratio was poorer at each of the cumulative periods ($P < .01$ to $P < .03$) of the experiment for cattle fed High Oil corn than for those fed Normal corn. For the entire 165-d feeding period, feed:gain was improved ($P < .01$) 7.5% for cattle fed Normal vs High Oil corn.

Although differences were observed between the two types of corn, performance by the steers in both groups was exceptional. Net energy values calculated from performance (NRC, 1996) were 2.30 and 1.61 Mcal/kg for NEm and NEg, respectively, for the Normal corn diet and 2.19 and 1.51 Mcal/kg for NEm and NEg, respectively, for the High Oil corn diet. Performance-based NE values were greater for the Normal corn diet than values calculated from tabular data for the feed ingredients (NRC, 1996; 2.16 and 1.48 for NEm and NEg, respectively). This represented a 6% increase in NEm and an 8.8% increase in NEg for performance-based values compared with tabular values for Normal corn.

Carcass Data. Carcass measurements are shown in Table 5. Hot carcass weight, dressing percent, fat thickness, KPH, and yield grade did not differ between treatments. Longissimus muscle area tended ($P < .07$) to be less in carcasses from cattle fed High Oil corn than from those fed Normal corn, and marbling score was 7.4% less ($P < .01$) with High Oil than with Normal corn. Despite the difference in marbling score, percentage of carcasses grading USDA Choice was very similar (Chi-square = $P > .80$) between the two groups (84.75% vs 82.76% for Normal and High Oil carcasses, respectively). Two carcasses in each treatment group were dark cutters, and the reduction in quality grade associated with dark cutting resulted in a slightly higher percentage of carcasses that graded USDA Standard with the Normal corn treatment.

Liver score data are shown in Table 6. Approximately two-thirds of the livers from steers in the two treatments had no indications of abscesses or other problems, and occurrence rates for liver abscess and telangiectasis were low in both groups. Condemnation as a result of distoma (presumably liver fluke damage) was considerably higher in livers from steers fed High Oil corn (25.86%) than in livers from steers fed Normal corn (10.17%). Liver flukes typically account for 22% of all condemnations (Nagaraja and Chengappa, 1998). The difference between the two treatments in the percentage of condemned livers as a result of flukes might have impacted performance results because Hicks et al. (1989) reported that for each 10% incidence in liver flukes, daily gain by feedlot steers was decreased by approximately .03 lb/d. However, evaluation of the individual daily gain data for the two treatments in the present experiment revealed essentially equal or slightly greater daily gain by steers that had liver flukes compared to those in other liver score categories, suggesting that differences in liver flukes had little effect on the daily gain results.

Summary and Conclusions

Under the conditions of the present experiment, feeding steam-flaked high oil corn to finishing steers for 165 d resulted in a 5.1% decrease ($P < .04$) in daily gain, no change in DMI, and a 7.5% poorer feed:gain ratio than feeding normal corn plus added fat. Reasons for the slightly decreased performance with high oil corn are not readily evident. Composition of the diets (Table 3) was similar, although ether extract content was slightly less for the high oil corn diet than for the normal diet, which might have affected the results. It is possible that differences in the response of high oil and normal corn to steam flaking might be responsible for all or part of these differences. Evaluation of samples of steam-flaked corn collected during the experiment indicated little difference in percentage of available starch (by enzymatic glucose release) for normal vs high oil corn (H. M. Derington, unpublished data). Physical characteristics of the two types of steam-flaked corn differed, with flake integrity being noticeably different between normal and high oil corn. Flakes of steam-flaked high oil corn fractured readily after production, but the extent to which this difference might have influenced performance results is unknown.

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Table 1. Ingredient composition (%, DM basis) of the experimental diets

	Percentage of dietary concentrate							
	60		70		80		90	
Ingredient	N[a]	HO[a]	N	HO	N	HO	N	HO
Cottonseed hulls	24.93	25.19	19.91	20.16	14.50	14.49	5.04	4.95
Ground alfalfa hay	14.70	14.82	9.76	9.93	4.88	4.91	5.04	5.05
Steam-flaked corn	43.02	45.12	52.48	54.90	63.00	66.50	73.59	76.75
Cottonseed meal	7.06	7.50	6.92	7.48	6.58	7.06	5.02	5.79
Molasses	4.20	4.18	4.14	4.22	3.77	3.79	3.99	4.00
Fat (yellow grease)	2.94	-	3.54	-	4.01	-	3.86	-
Urea	.60	.61	.70	.72	.78	.77	.91	.91
TTU premix[b]	2.55	2.58	2.55	2.59	2.48	2.48	2.55	2.55

[a]N = mill-run corn plus added fat. HO = high oil corn.

[b]Premix composition is shown in Table 2.

Table 2. Composition of the TTU premix used in experimental diets

Ingredient	%, DM basis
Cottonseed meal	23.9733
High-calcium limestone	42.1053
Dicalcium phosphate	1.0363
Potassium chloride	8.0000
Magnesium oxide	3.5587
Ammonium sulfate	6.6667
Salt	12.0000
Cobalt carbonate	.0017
Copper sulfate	.1572
Iron sulfate	.1333
EDDI	.0025
Manganese oxide	.2667
Selenium premix, .2%	.1000
Zinc sulfate	.8251
Vitamin A, 650,000 IU/g[a]	.0122
Vitamin E, 275 IU/g[a]	.1260
Rumensin, 80 mg/lb[a]	.6750
Tylan, 40 mg/lb[a]	.3600

[a]Concentrations noted by the ingredient are on a 90% DM basis.

Table 3. Chemical composition of the experimental diets

	Percentage of dietary concentrate					
	70		80		90	
Item	N[a]	HO[a]	N	HO	N	HO
Dry matter, %[b]	84.95	84.68	80.74	81.43	81.04	80.20
Ash, %	4.54	5.21	4.27	4.41	4.04	4.25
Crude protein, %	11.74	12.66	13.08	12.69	13.37	14.12
Ether extract, %	7.24	7.12	7.41	7.08	7.09	6.50
Acid detergent fiber, %	16.85	17.65	11.53	14.23	6.55	7.18
Calcium, %	.53	.55	.45	.57	.47	.43
Phosphorus, %	.20	.23	.25	.26	.31	.29

[a]N = mill-run corn plus added fat. HO = high oil corn. Samples were not available for analysis of the 60% concentrate diets.

[b]All values except Dry matter, % are expressed on a DM basis. Values represent analyses conducted on a sample of each diet composited across the experiment.

Table 4. Effects of normal corn plus added fat and high oil corn on performance by finishing beef steers

Item	Type of corn[a]		SE[b]	OSL[c]
	Normal	High oil		
Initial BW, lb	631.1	637.3	3.82	NS
Final BW, lb	1,305.0	1,276.7	10.77	.08
Daily gain, lb				
d 0 to 28	4.21	3.82	.116	.03
d 0 to 56	4.44	4.24	.083	NS
d 0 to 84	4.44	4.10	.085	.02
d 0 to 112	4.36	4.17	.077	.10
d 0 to 140	4.10	3.96	.073	NS
d 0 to 165	4.09	3.88	.066	.04
Daily DMI, lb/steer				
d 0 to 28	15.37	15.35	.050	NS
d 0 to 56	17.02	17.22	.120	NS
d 0 to 84	17.47	17.50	.158	NS
d 0 to 112	17.93	18.06	.180	NS
d 0 to 140	18.32	18.66	.206	NS
d 0 to 165	18.62	19.09	.212	NS
Feed:gain				
d 0 to 28	3.68	4.06	.117	.03
d 0 to 56	3.85	4.07	.067	.03
d 0 to 84	3.94	4.28	.074	.01
d 0 to 112	4.12	4.34	.054	.01
d 0 to 140	4.47	4.72	.049	.01
d 0 to 165	4.56	4.93	.044	.01

[a]Normal = mill-run corn plus added fat. High oil = high oil corn.

[b]Pooled standard error of treatment means, n = 12 pens/treatment.

[c]OSL = observed significance level for comparison of treatment means. NS = non-significant, $P > .10$.

Table 5. Effects of normal corn plus added fat and high oil corn on carcass characteristics of finishing beef steers

	Type of corn[a]			
Item	Normal	High oil	SE[b]	OSL[c]
Hot carcass wt, lb	805.1	795.6	8.94	NS
Dressing percent	61.97	62.34	.251	NS
LM area[d], sq. in.	14.24	13.90	.113	.07
Fat thickness, in.	.62	.60	.023	NS
KPH[e], %	2.04	2.00	.051	NS
Yield grade	3.26	3.33	.069	NS
Marbling score[f]	476.6	441.4	8.38	.01
Choice, %[g]	84.75	82.76	-	-
Select, %	10.17	15.52	-	-
Standard, %	5.08	1.72	-	-

[a]Normal = mill-run corn plus added fat. High oil = high oil corn.

[b]Pooled standard error of treatment means, n = 12 pens/treatment.

[c]OSL = observed significance level for comparison of treatment means. NS = non-significant, $P > .10$.

[d]LM = longissimus muscle.

[e]KPH = kidney, pelvic, and heart fat.

[f]300 = Slight^0; 400 = Small^0; 500 = Modest^0.

[g]Choice, % includes cattle that graded Prime. Distribution of quality grades did not differ ($P > .80$) between treatments.

Table 6. Distribution of liver scores (% of total) in finishing beef steers fed normal corn plus added fat or high oil corn

	Type of corn[a]	
Item	Normal	High oil
Not condemned	68.97	65.53
A-	6.90	1.72
A	0.00	0.00
A+	1.72	0.00
Telangiectasis	5.17	1.72
Distoma (fluke)	10.34	25.86
Comtamination[b]	6.90	5.17

[a]Normal = mill-run corn plus added fat. High oil = high oil corn.

[b]Liver condemned because of contamination with feces or digestive tract contents at the plant.