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Effects of bulk density of steam-flaked corn and dietary roughage concentration on performance and carcass characteristics of finishing beef steers

K. E. Hales, J. P. McMeniman, J. T. Vasconcelos, J. Leibovich, R. J. Rathmann,
J. C. DeClerck, and M. L. Galyean

Department of Animal and Food Sciences
Texas Tech University, Lubbock 79409-2141

Introduction

Steam flaking is the most common grain processing method used by beef feedlots in the High Plains (Galyean and Gleghorn, 2001; Vasconcelos and Galyean, 2007); however, costs associated with natural gas and electricity used in steam flaking are substantial. Decreasing bulk density of steam-flaked grains increases gelatinization of starch, but mill production costs are greater with lighter flake weights. Dietary concentration of roughage, particularly of neutral detergent fiber (**NDF**) from roughage is closely associated with net energy for gain (**NE_g**) intake by feedlot cattle (Galyean and Defoor, 2003), and small increases in dietary NDF from roughage sometimes increase **NE_g** intake and thereby average daily gain (**ADG**; Galyean and Abney, 2006). At the present time, costs of traditional roughage sources are high; thus, as long as **NE_g** intake (and thereby **ADG**) can be maintained at a reasonable level, minimizing roughage concentrations in feedlot diets is a logical approach to improve cost of gain.

Given that increasing the bulk density of steam-flaked corn (**SFC**) would likely result in increased dry matter intake (**DMI**) by finishing cattle, it is possible that roughage concentration could be decreased as bulk density of **SFC** is increased. Increasing flake weight should decrease energy costs associated with steam flaking, whereas

decreasing roughage concentrations should lower overall feed costs. Therefore, the objective of the present experiment was to evaluate the effects of 2 bulk densities of **SFC** (26 and 30 lb/bu) and 2 roughage concentrations (6 and 10% of dietary **DM**) on performance and carcass characteristics of finishing beef steers.

Experimental Procedures

Cattle. Approximately 180 beef steers (British and British x Continental breeding; arrival body weight [**BW**] = 835 lb) were delivered to the Texas Tech University Burnett Center at New Deal, TX. After arrival, steers were weighed individually, tagged in the ear with an individual identification tag, vaccinated with Vision 7 with SPUR (Intervet Inc., Millsboro, DE) and Vista 5 SQ (Intervet Inc.), and dewormed with Cydectin (Fort Dodge Animal Health Inc., Overland Park, KS). After processing, steers were fed a 65% concentrate starter diet and then stepped up to a 75% concentrate diet in approximately 7 to 10 d. The steers were weighed, and 128 were selected on the basis of uniformity of **BW** for use in the experiment. Selected steers were blocked by **BW** and sorted to 32 concrete, partially slotted floor pens (4 steers/pen; 9.5-foot x 18.33-foot with 8 feet of bunk space.) Treatments were assigned randomly to pens within blocks (1 pen/treatment within 8 blocks), resulting in a total of 8 pens (32 steers)/treatment. The

cattle were weighed individually, implanted with Revalor S (Intervet, Inc.), and switched to the treatment diets to initiate the experiment. At the time the experiment began, the cattle were stepped up to an 85% concentrate diet and then switched approximately 1 wk later to the final diets (described below) for the remainder of the experiment.

Experimental Design and Treatment and Pen Assignment. Treatments were arranged in a 2 x 2 factorial with the factors of bulk density of SFC (26 or 30 lb/bu) and roughage concentration (6 or 10% coarsely ground [approximately 1-inch chop length] alfalfa hay on a DM basis). Thus, the 4 resulting treatment combinations consisted of: (1) 26 lb/bu bulk density with 6% roughage (**26-6**); (2) 26 lb/bu bulk density with 10% roughage (**26-10**); (3) 30 lb/bu bulk density with 6% roughage (**30-6**); and (4) 30 lb/bu bulk density with 10% roughage (**30-10**). Diets were formulated to contain 13.5% CP and 3% supplemental fat (DM basis). Rumensin (30 g/ton) and Tylan (10 g/ton) along with various vitamins and minerals were supplied by a premix that was included as 3% of the dietary DM.

Whole corn grain was conditioned in a an auger by adding 6 ounces/ton of E-Z Flake surfactant (Animal Feed Technologies, LLC, Greeley, CO) into the volume of water necessary to increase the moisture content of the grain to 17%. The whole corn grain was then steamed for approximately 30 min at 200°F in a vertical steam chamber, which increased the moisture content to about 20%. The capacity of the steam chamber is approximately 5,000 lb of whole corn grain. Steamed grain was passed through the roller mill (18 in x 24 in) to produce the bulk densities of 26 or 30 lb/bu. Corn bulk density was monitored each time fresh

supplies were produced to ensure that the targets were achieved. The average moisture content of the 26 lb/bu bulk density treatment was 20.1%, whereas moisture content of the 30 lb/bu treatment averaged 20.3%.

Feeding, Weighing, Routine Management, and Sampling. Feed bunks were evaluated visually each day of the experiment to determine the quantity of feed to offer to each pen. The bunk management approach was designed to allow for 0 to 0.5 lb of feed remaining in the feed bunk at the time of evaluation. After the quantity of feed to be provided to each pen was determined, a batch of each diet sufficient to supply the feed for all the pens on a given treatment was mixed in the feed mill (45-cubic foot Marion paddle mixer). After mixing, each diet was conveyed to a Rotomix 84-8 mixer unit mounted on load cells and pulled by a tractor. The feed for each pen on a given treatment was delivered via the Rotomix 84-8 unit (scale readability ± 1 lb). Cleanout of the mixer was monitored to ensure that cross-contamination of diets was minimized. Samples of dietary ingredients were taken every 2 wk during the experiment to determine DM content. Samples of feed from the 8 pens/treatment were collected weekly throughout the experiment and composited within weigh periods. Composited feed bunk samples were subsequently analyzed for DM, CP, acid detergent fiber, fat (ether extract), Ca, P, and K by SDK Laboratories (Hutchinson, KS).

All steers were weighed individually (scale readability ± 1 lb; scale calibrated with 1,000 lb of certified weights before use) at the start of the experiment (d 0) and before shipment to slaughter. Pen-based interim weights (scale readability ± 5 lb; scale calibrated with 1,000 lb of certified

weights before use) were obtained every 35 d. At each weigh period, feed bunks were swept, and any feed remaining in the bunks was weighed and its DM content determined. When approximately 60% of the steers in a weight block were deemed to have sufficient finish to grade USDA Choice, they were sent via commercial transport to a federally inspected slaughter facility for collection of carcass data.

Carcass Evaluation. Personnel of the Texas Tech University Meat Laboratory collected carcass data, including yield grade, quality grade, marbling score, percentage of kidney, heart, and pelvic fat (**KPH**), longissimus muscle (**LM**) area, fat thickness at the 12th rib, and liver abscess score.

Statistical Analyses. Animal performance and carcass data were analyzed with pen as the experimental unit in a randomized complete block design using the Mixed procedure of SAS (SAS Inst. Inc., Cary, NC). Pen means for ADG and DM intake were included in the data file, and gain:feed ratio (**G:F**) was computed as the quotient of ADG divided by daily DMI. The random effect of block was included in the model, and the fixed effects of flake bulk density, roughage concentration, and the flake bulk density x roughage concentration interaction were evaluated by single degree-of-freedom *F*-tests. When significant bulk density x roughage concentration interactions were detected, pairwise comparisons of the simple-effect means were conducted with the PDIFF option of the Mixed procedure. The proportion of cattle grading USDA Choice or greater was analyzed as a binomial proportion using the Glimmix procedure of SAS, with block as a random effect.

Results and Discussion

Chemical composition of the diet (Table 1) was generally similar to values expected from formulation. Fat content of the 30 lb/bu SFC diets was approximately 0.7% greater than noted with the 26 lb/bu diets. To our knowledge, changes in fat content as a result of steam flaking have not been reported previously; however, CP concentration decreased when sorghum was steam flaked vs. dry rolled (Defoor et al., 2000). Reasons for loss of CP with steam flaking are not clear; however, Defoor et al. (2000) suggested that removal and loss of portions of the grain germ and seed coat during steam flaking might contribute to the lower concentration of CP. Further investigation is necessary to determine whether the lowered fat content in our 26 lb/bu diets was associated with the steam-flaking process.

No interactions were observed between bulk density and roughage concentration ($P \geq 0.33$) for any of the variables measured, except for percentage of carcasses grading USDA Choice or greater ($P = 0.07$). Therefore, the main effects of bulk density and roughage concentration will be discussed.

Body Weight and Average Daily Gain

Initial BW did not differ between the 2 bulk density treatments (Table 2). Similarly, final live BW (unshrunk; $P = 0.30$) and carcass-adjusted final BW ($P = 0.51$) did not differ between the flake densities. As a result, no differences were observed for ADG between 26 and 30 lb/bu bulk densities, except for a tendency ($P = 0.11$) for greater ADG by cattle fed the 26 lb/bu bulk density from d 0 to 105 (Table 2).

Similar to results with flake density, initial BW did not differ between the 2 dietary roughage concentrations (Table 2). Final unshrunk live BW ($P = 0.99$) and carcass-adjusted final BW ($P = 0.23$) also were not affected by roughage concentration. The ADG did not differ between roughage concentrations for the overall feeding period, although there was a tendency ($P = 0.09$) for a greater ADG by cattle fed 10 vs. 6% roughage concentration during the first 35 d of the feeding period.

Dry Matter Intake

Bulk density of flaked corn affected DMI from d 0 to 35 ($P = 0.07$), with lower intake by cattle fed 26 lb/bu flakes compared with those fed 30 lb/bu. No further differences in DMI were observed for the 2 flake density treatments during the remainder of the feeding period ($P \geq 0.37$).

Dry matter intake was less by cattle fed 6 vs. 10% roughage concentration from d 0 to 35 ($P = 0.03$) and d 0 to 70 ($P = 0.05$), but it did not differ from d 0 to 105 ($P = 0.16$). For the overall feeding period, DMI did not differ ($P = 0.35$) between the 2 roughage concentrations.

Gain Efficiency

Cattle fed the 26 lb/bu bulk density had greater G:F than cattle fed 30 lb/bu SFC from d 0 to 105 ($P < 0.01$) and from d 0 to end ($P = 0.04$). This pattern of greater G:F with the lower flake weight also was evident from d 0 to 35 ($P = 0.09$) and d 0 to 70 ($P = 0.10$). Carcass-adjusted G:F did not differ between treatments ($P = 0.20$) for from d 0 to end, presumably reflecting a slightly lower dressing percent for cattle fed the 26 lb/bu SFC.

No differences ($P \geq 0.14$) were observed between roughage concentration treatments for G:F, except for a tendency for lower G:F from d 0 to end ($P = 0.09$) by cattle fed 10% roughage. Likewise, no differences ($P = 0.69$) were observed between treatments for carcass-adjusted G:F from d 0 to end.

Carcass Characteristics

Hot carcass weight (**HCW**; $P = 0.51$), dressing percent ($P = 0.48$), LM area ($P = 0.94$), fat thickness ($P = 0.81$), KPH ($P = 0.88$), yield grade ($P = 0.77$), marbling score ($P = 0.48$), and liver abscesses ($P = 0.77$) did not differ between the 2 bulk density treatments (Table 3). Cattle fed the 30 lb/bu treatment tended ($P = 0.07$) to have a greater percentage of carcasses grading Choice or greater than cattle fed the 26 lb/bu treatment (Table 3).

No differences were observed between the 2 dietary roughage concentrations for HCW ($P = 0.23$), LM area ($P = 0.78$), fat thickness ($P = 0.43$), yield grade ($P = 0.86$), marbling score ($P = 0.95$), percentage of carcasses grading Choice or greater ($P = 0.22$) and liver abscesses ($P = 0.68$). Cattle fed the 10% roughage concentration treatment had a greater dressing percent ($P = 0.01$) and lower KPH ($P < 0.01$) than cattle fed 6% roughage.

As noted previously, an interaction ($P = 0.07$) was observed between SFC bulk density and roughage concentration for percentage of carcasses grading USDA Choice or greater. Evaluation of the simple-effect means (Table 4) for bulk density and roughage concentration combinations indicated that the percentage of carcasses grading Choice did not differ between cattle fed 26 lb/bu bulk density treatments with either level of roughage and the 30 lb/bu treatment with 6% roughage. In contrast,

cattle fed 30 lb/bu SFC bulk density treatment with 10% roughage had a greater ($P < 0.05$) percentage of carcasses that graded Choice than carcasses of cattle in the other 3 treatments.

Conclusions

Under the conditions of the present study, no interactions were observed between bulk density and roughage concentrations for the performance traits and most of the carcass traits measured. Our data suggest that cattle fed 26 lb/bu bulk density SFC were more efficient than those fed 30 lb/bu SFC. Vasconcelos and Galyean (2007) reported that, on average, feedlot consulting nutritionists recommend a bulk density of SFC of 27 lb/bu; however, the most frequently used bulk density (mode) in their survey was 28 lb/bu. Thus, the 26 lb/bu flake in the current experiment is only slightly less than the bulk density typically used in commercial feedlots. Furthermore, cattle fed 6% roughage concentration tended to be more efficient than those fed 10% dietary roughage. Thus, with the ranges of bulk density and roughage concentration we evaluated, it should be possible to achieve increased G:F by simultaneously decreasing bulk density of SFC and dietary roughage concentration.

Literature Cited

- Defoor, P. J., M. L. Galyean, N. A. Cole, and O. R. Jones. 2000. Effect of planting density and processing method on laboratory characteristics of grain sorghum for ruminants. *J. Anim. Sci.* 78:2032-2038.
- Galyean, M. L., and C. S. Abney. 2006. Assessing roughage value in diets of high-producing cattle. Pages 127-144 in *Proc. Southwest Nutr. Manage. Conf.*, Univ. of Arizona, Tucson.
- Galyean, M. L., and P. J. Defoor. 2003. Effects of roughage source and level on intake by feedlot cattle. *J. Anim. Sci.* 81(E. Suppl. 2):E8-E16.
- Galyean, M. L., and J. F. Gleghorn. 2001. Summary of the 2000 Texas Tech University Consulting Nutritionist Survey. Burnett Center Internet Prog. Rep. No. 12, Texas Tech Univ. Available: http://www.asft.ttu.edu/burnett_center/progress_reports/bc12.pdf. Accessed May 3, 2006.
- Vasconcelos, J. T., and M. L. Galyean. 2007. Nutritional recommendations of feedlot consulting nutritionists: The 2007 Texas Tech University survey. *J. Anim. Sci.* 85:2772-2781.

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Table 1. Composition and analyzed nutrient content (DM basis) of diets based on steam-flaked corn (SFC) processed to different bulk densities and fed with different roughage concentrations¹

Item	SFC bulk density, lb/bu:	26		30	
	Roughage in diet, %	6	10	6	10
Ingredient					
Steam-flaked corn		77.66	74.37	77.69	74.41
Ground alfalfa hay		6.14	10.23	6.14	10.22
Cottonseed meal		5.22	4.41	5.21	4.40
Urea		0.90	0.91	0.90	0.91
Fat		3.94	3.94	3.94	3.93
Molasses		3.05	3.05	3.04	3.05
Supplement ²		3.09	3.09	3.08	3.08
Analyzed composition					
CP, %		13.15	13.29	13.51	13.15
ADF, %		7.99	8.83	8.33	8.94
Fat, %		5.15	5.25	5.80	5.98
Ca, %		0.58	0.66	0.64	0.58
P, %		0.28	0.26	0.32	0.30
K, %		0.74	0.78	0.77	0.87

¹Steam-flaked corn was processed to a bulk density of 26 or 30 lb/bu; dietary roughage concentration was either 6 or 10% of dietary DM.

²Supplement contained (DM basis): 27.841% cottonseed meal; 0.500% Endox (antioxidant; Kemira Industries, Des Moines, IA); 35.088% limestone; 0.432% dicalcium phosphate; 6.667% potassium chloride; 14.493% MIN-AD (MIN-AD Corp, Amarillo, TX); 3.559% magnesium oxide; 2.778% ammonium sulfate; 10.000% salt; 0.001% cobalt carbonate; 0.131% copper sulfate; 0.056% iron sulfate; 0.002% ethylenediamine dihydroiodide; 0.222% manganese oxide; 0.083% selenium premix (0.2% Se); 0.657% zinc sulfate; 0.007% vitamin A (1,000,000 IU/g); 0.105% vitamin E (500 IU/g); 0.562% Rumensin (176.4 mg/kg; Elanco Animal Health, Indianapolis, IN); and 0.375% Tylan (88.2 mg/kg; Elanco Animal Health). Concentrations in parenthesis are expressed on a 90% DM basis.

Table 2. Effects of bulk density of steam-flaked corn and dietary roughage concentration on performance by finishing beef steers

Item	Bulk density, lb/bu ¹		<i>P</i> -value ²	Dietary roughage, % ¹		<i>P</i> -value ²	SE ³
	26	30		6	10		
Initial BW, lb	868.1	869.3	0.78	866.1	871.4	0.21	25.40
Final BW, lb	1,311.9	1,299.1	0.30	1,305.6	1,305.4	0.99	23.07
Adjusted final BW, lb ⁴	1,310.0	1,301.4	0.51	1,297.8	1,313.6	0.23	25.01
Daily gain, lb							
d 0 to 35	4.09	4.01	0.63	3.91	4.20	0.09	0.124
d 0 to 70	4.01	3.94	0.52	3.93	4.01	0.44	0.087
d 0 to 105	3.84	3.71	0.11	3.78	3.77	0.88	0.066
d 0 to end ⁵	3.55	3.44	0.20	3.52	3.47	0.53	0.087
Adjusted, d 0 to end ⁴	3.54	3.46	0.35	3.46	3.54	0.36	0.097
Daily DMI, lb/steer							
d 0 to 35	16.77	17.31	0.07	16.71	17.37	0.03	0.316
d 0 to 70	18.43	18.69	0.37	18.26	18.86	0.05	0.326
d 0 to 105	19.10	19.30	0.46	19.00	19.40	0.16	0.340
d 0 to end ⁵	19.11	19.20	0.76	19.02	19.29	0.35	0.340
Gain:feed							
d 0 to 35	0.244	0.231	0.09	0.233	0.242	0.24	0.0050
d 0 to 70	0.217	0.211	0.10	0.215	0.213	0.59	0.0027
d 0 to 105	0.201	0.192	<0.01	0.199	0.194	0.14	0.0022
d 0 to end ⁵	0.186	0.179	0.04	0.185	0.180	0.09	0.0021
Adjusted, d 0 to end ⁴	0.185	0.180	0.20	0.182	0.183	0.69	0.0026

¹Steam-flaked corn was processed to a bulk density of 26 or 30 lb/bu; dietary roughage concentration was either 6 or 10% of dietary DM. No bulk density x roughage concentration interactions were detected, $P \geq 0.33$.

²Observed significance levels for bulk density or roughage concentration main-effect comparisons.

³Pooled standard error of main-effect means, n = 16 pens/main-effect mean.

⁴Adjusted final BW equaled hot carcass weight divided by average dressing percent (61.98%). Adjusted daily gain (d 0 to end) was calculated from the adjusted final BW and the initial BW, and adjusted gain:feed (d 0 to end) was calculated as the ratio of adjusted daily gain (d 0 to end) to d 0 to end DMI.

⁵Cattle in the blocks through 1 through 4 were on feed for 136 d, whereas cattle in the blocks 4 through 8 were on feed for 115 d, resulting in an average of 125.5 d on feed.

Table 3. Effects of bulk density of steam-flaked corn and dietary roughage concentration on carcass characteristics of finishing beef steers

Item	Bulk density, lb/bu ¹			Dietary roughage, % ¹			SE ³
	26	30	<i>P</i> -value ²	6	10	<i>P</i> -value ²	
Hot carcass wt, lb	811.9	806.5	0.51	804.3	814.1	0.23	15.50
Dressing percent	61.88	62.07	0.48	61.57	62.39	0.01	0.191
LM area ⁴ , sq. in.	12.78	12.80	0.94	12.75	12.83	0.78	0.294
12 th rib fat, in.	0.56	0.55	0.81	0.54	0.57	0.43	0.024
KPH, % ⁴	3.38	3.40	0.88	3.61	3.17	<0.01	0.170
Yield grade	3.77	3.73	0.77	3.76	3.74	0.86	0.123
Marbling score ⁴	431.5	444.1	0.48	438.3	437.2	0.95	13.27
Choice ^{5,6} , %	52.60	68.75	0.07	56.25	65.10	0.22	-
Select ^{6,7} , %	47.40	31.25	-	43.75	34.90	-	-
Abscessed livers ⁸ , %	9.38	10.94	0.77	9.38	10.94	0.68	-

¹Steam-flaked corn was processed to a bulk density of 26 or 30 lb/bu; dietary roughage concentration was either 6 or 10% of dietary DM. No bulk density x roughage concentration interactions were detected ($P \geq 0.17$), except as noted below for quality grade data.

²Observed significance level for bulk density or roughage concentration main-effect comparisons.

³Pooled standard error of main-effect means, $n = 16$ pens/main-effect mean.

⁴LM = longissimus muscle; KPH = kidney, pelvic, and heart fat; Marbling score: 300 = Slight⁰; 400 = Small⁰; 500 = Modest⁰.

⁵Bulk density x roughage concentration interaction, $P = 0.07$.

⁶Choice = USDA Choice or greater; Select = USDA Select or less.

⁷ P -values for Select or less are identical to the Choice or greater values.

⁸Sum of A-, A, and A+ liver abscess scores.

Table 4. Simple-effect means for percentage of carcasses grading USDA Choice or greater, which showed a significant ($P \leq 0.06$) steam-flaked corn (SFC) bulk density x roughage concentration interaction¹

Item	SFC bulk density, lb/bu:		26		30		SE ²
	Roughage concentration, %:		6	10	6	10	
Marbling score ³			444.4	418.5	432.2	455.9	18.08
Choice or greater, %			56.25 ^a	48.96 ^a	56.25 ^a	81.25 ^b	-
Select or less, %			43.75	51.04	43.75	18.75	-

¹Steam-flaked corn was processed to a bulk density of 26 or 30 lb/bu; dietary roughage concentration was either 6 or 10% of dietary DM. The bulk density x roughage concentration interaction for marbling score was not significant ($P = 0.17$), but values are shown to illustrate changes in marbling score relative to changes in percentage of carcasses in the USDA Choice and Select quality grades.

²Pooled standard error of simple-effect means, $n = 8$ pens/simple-effect mean.

³Marbling score: 300 = Slight⁰; 400 = Small⁰; 500 = Modest⁰.

^{a,b}Row means with different superscripts differ, $P < 0.05$.