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Effects of Steam-Flaked Sorghum Grain or Corn and Supplemental Fat on Feedlot Performance, Carcass Traits, Longissimus Composition, and Sensory Properties of Steers[1]

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ABSTRACT: One hundred forty British × Exotic crossbred, yearling steers (370 kg) were used in a 2 × 2 factorial experiment to evaluate main effects and the interaction of grain type (steam-flaked sorghum grain [SFSG] or steam-flaked corn [SFC]) and level of supplemental fat (0 or 4% yellow grease [YG]) on feedlot performance, diet NE concentration, carcass traits, and chemical composition and sensory properties of longissimus muscle. Steer performance and estimated dietary NE_m and NE_g values were not different between SFSG and SFC. Supplemental YG improved ($P \leq .05$) gain/feed and estimated NE_m and NE_g of both SFSG and SFC diets. Compared with steers fed SFSG, steers fed SFC had a more yellow ($P < .05$) subcutaneous fat color. Supplemental YG had an additive effect ($P < .025$) on yellow color of subcutaneous fat but improved ($P < .08$) the lean color of longissimus muscle. Grain type or supplemental YG had no effect on sensory properties or mechanical shear of longissimus muscle. Longissimus muscle cholesterol content was elevated ($P < .05$) by supplemental YG (.49 vs .52 mg/g of wet tissue for 0 vs 4% YG, respectively); however, the biological significance of this result is questionable. Similarly, effects of YG on increased ($P < .05$) stearic acid concentration and a higher concentration ($P < .05$) of linoleic acid measured in longissimus muscle of steers fed SFSG vs SFC were small in magnitude. These data indicate that under the conditions of this experiment, NE contents of SFSG and SFC were similar. Beef produced from sorghum grain is similar in quality and sensory properties to that produced from corn. There was no correlation (r = −.001) between degree of marbling and tissue cholesterol content, suggesting that for closely trimmed beef cuts, selection for higher quality by consumers will not elevate cholesterol intake.

Key Words: Steers, Feedlots, Corn, Sorghum Grain, Fats, Palatability

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Introduction

Dry-rolled sorghum grain has 92 and 92.9% the NE_m and NE_g, respectively, of corn for beef cattle (NRC, 1984). Wet processing methods, including steam flaking, may result in a 12 to 20% improvement in feed efficiency of sorghum grain over dry rolling (Hale, 1984; NRC, 1984; Brandt et al., 1988a). Although several studies have evaluated the use of processed sorghum grain in cattle finishing rations (Hale, 1984; Stock et al., 1987), there have been few studies that directly compare the feeding value of steam-flaked sorghum grain (SFSG) and steam-flaked corn (SFC). Additionally, the relative value of supplemental fat in flaked corn vs sorghum rations is unknown, although Hale et al. (1984) indicated that sorghum rations may benefit more from supplemental fat than would corn rations. However, no direct comparisons are available. Further, data on the chemical and sensory effects of these treatments on carcass beef are not available, yet data are needed to either document or disprove the belief by some that feeding

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sorghum grain has a detrimental effect on the quality of beef.

Thus, the objectives of our studies were 1) to compare the energy value of SFSG vs SFC finishing diets, 2) to evaluate the main effect and potential interaction of supplemental fat with grain type on steer performance and carcass traits, and 3) to measure treatment effects on chemical composition and sensory traits of beef longissimus muscle.

Materials and Methods

Animals and Diets. One hundred forty British × Exotic crossbred, yearling steers (370 kg) were used in a 2 × 2 factorially arranged, randomized complete block experiment. Main effect factors were grain type (SFSG or SFC) and level of yellow grease (YG; 0 or 4% of diet DM). Before the study, steers were implanted with estradiol (Compudose®, Elanco Products, Indianapolis, IN), treated for internal and external parasites with fenbendazole (Safe-Guard®, Hoechst-Roussel Agri-Vet Co., Somerville, NJ) and trichlorfon (Neguvon®, Cutter Animal Health, Shawnee, KS), respectively, and vaccinated against infectious bovine rhinotracheitis, parainfluenza-3, bovine viral diarrhea (modified live virus), and seven clostridial organisms. Initial and final weights were the average of early morning full weights taken on two consecutive days.

Table 1. Percentage composition of steam-flaked sorghum grain (SFSG) or corn (SFC) diets containing 0 or 4% yellow grease[a]

Ingredient or nutrient	SFSG 0%	SFSG 4%	SFC 0%	SFC 4%
SFSG	78.8	78.2	—	—
SFC	—	—	76.1	75.5
Alfalfa hay	10.0	10.0	10.0	10.0
Pelleted supplement[b]	5.2	5.2	5.2	5.2
Cottonseed meal	—	.6	2.7	3.3
Yellow grease	—	4.0	—	4.0
Cane molasses	6.0	2.0	6.0	2.0
Chemical analysis				
CP	12.48	12.58	12.63	12.66
Ca	.69	.71	.72	.73
P	.34	.32	.33	.36
K	.76	.71	.74	.70

[a] Dry basis. Vitamin A (2,200 IU/kg) and E (10 IU/kg), monensin (28 ppm), and tylosin (11 ppm) were added daily by way of a microingredient machine.

[b] Contained 28.8% wheat middlings, 22.1% limestone, 20.4% dehydrated alfalfa, 10.7% urea, 5.6% salt, 3.5% dicalcium phosphate, 3.7% KCl, 2.7% $(NH_4)_2SO_4$, 2.0% mineral oil, and .5% trace minerals.

Table 2. Chemical analysis of yellow grease

Item	%
Moisture (M)	.02
Insoluble impurities (I)	.01
Unsaponifiable matter (U)	1.94
Total MIU	1.97
Free fatty acids	12.30
Total fatty acids	95.64
Fatty acid profile	
C12	.1
C14	2.5
C15	.4
C16	21.4
C16:1	3.4
C17	.9
C17:1	.6
C18	13.8
C18:1	43.4
C18:2	11.1
C18:3	.8
Others	1.4

After an adaptation period of 11 d, during which time animals were fed identical corn-based step-up rations, initial weights were obtained. Steers were allotted by weight into five weight replicates and randomly allotted within weight replicate to one of four pens. The result was five pens of seven steers per treatment combination. Diets (Table 1) were formulated to contain 13% CP by substituting an appropriate level of cottonseed meal for the respective grain. Steam-flaked sorghum grain and SFC were flaked to 335 and 257 g/L (26 and 20 lb/bu), respectively. Both grains were flaked and fed fresh daily. Steaming times were adjusted such that average moisture content of SFSG and SFC from samples collected just below the rolls was 18.9 and 19.1%, respectively. Yellow grease (composition given in Table 2) replaced 4% of molasses in diets receiving no supplemental fat, to minimize the possibility that ration condition would affect intake and performance. Diet NE concentrations were estimated by previously described procedures (Brandt and Anderson, 1990). The trial was conducted for 100 d (October to January) at the Southwest Kansas Research-Extension Center, Garden City.

Final weights were obtained when approximately 70% of the steers were visually appraised to grade Choice. Steers were transported to a commercial packing plant and slaughtered. Hot carcass weights were obtained, and the incidence and severity of liver abscesses were recorded. Following a 24-h chill, carcass data were obtained.

Longissimus Muscle Sampling Methods. A 6.35-cm-thick longissimus section at the 11-12th rib from 80 of the carcasses (four steers per pen, selected at random) was taken for subsequent chemical composition, shear force, and sensory panel analyses. Samples were vacuum-packaged at the packing plant upon removal from the carcass and then frozen and stored at −40°C for approximately 4 mo before evaluation. Frozen sections were cut into three 2.54-cm steaks for sensory panel, shear force, and chemical analyses. Steaks for sensory panel and shear force testing were vacuum-packaged immediately after separation and replaced in the freezer (−40°C) before any detectable thawing occurred. The remaining steaks had all surface fat, epimysial connective tissue, and muscles other than the longissimus removed and then were vacuum-packaged and replaced in the freezer (−40°C) for later chemical analysis.

Longissimus Muscle Chemical Analysis. Sections were prepared for chemical analysis by immersion in liquid nitrogen, shattering, and blending with liquid nitrogen to produce uniform samples for proximate analysis (AOAC, 1984), fatty acid profiles (Brooks, 1967), and cholesterol content (Brooks, 1967; Goldy, 1989). Blended samples were stored in a nitrogen atmosphere at −65°C until they were analyzed.

Longissimus Muscle Sensory Analysis. Samples for sensory analysis were thawed at 2°C for 24 h and then cooked in a 163°C forced-air oven (Blodgett Dual Flow) to an internal temperature of 70°C. Temperature was monitored with type T thermocouples attached to a Doric Datalogger (Model 205, Beckman Industrial Corp., San Diego, CA). Cores (1.27 cm in diameter) were served warm to a trained taste panel (AMSA, 1978) that rated the samples for beef flavor intensity, juiciness, myofibrillar tenderness, connective tissue amount, overall tenderness, and off-flavor intensity. No more than eight samples were presented at one session, and panelists cleared their palates with unsalted crackers and water between samples. Panelists were in individual booths with red lighting during panel sessions.

Shear Analysis. Each steak was allowed to cool for 2 h and eight cores (1.27 cm) were removed and sheared with a Warner-Bratzler head moving at 250 mm/min on an Instron Universal Testing Machine (Model 4201, Instron, Canton, MA).

Data Analysis. Pen data were analyzed using the GLM procedure of SAS (1988). Model effects included weight replicate, grain type, yellow grease level, and grain type × yellow grease level interaction.

Results and Discussion

Steer Performance. Daily gain, feed consumption, and gain efficiency (gain/feed) were unaffected by grain type (Table 3). Also, estimated diet NE_m and NE_g concentrations were similar for SFSG and SFC. These data suggest that the NE value of sorghum grain can be elevated to that of SFC by steam flaking. It is emphasized that other factors, including degree of processing (Xiong et al., 1990) and bulk density of the unprocessed grain, can affect the energy value of SFSG. Low bulk density may be the result of small sorghum berries, which are difficult to process adequately, or grain chaff and dust, which dilute energy concentration. The fact that DM consumption and incidence of liver abscesses were similar between SFSG and SFC indicates that both grains were processed to a similar extent in this study.

Supplemental YG improved ($P < .05$) gain efficiency (gain/feed) of steers fed SFSG and SFC by 4.9 and 7.1%, respectively. Further, estimated diet NE_m and NE_g concentrations were elevated ($P \le .05$) by supplemental YG. Similar improvements have been previously reported for fat additions to SFSG-based diets (Hale et al., 1984; Brandt et al., 1988b; Brandt and Anderson, 1990). However, negative responses to supplemental fat in corn-

Table 3. Performance of finishing yearling steers fed steam-flaked sorghum grain (SFSG) or corn (SFC) diets containing 0 or 4% yellow grease

	SFSG		SFC		
Item	0%	4%	0%	4%	SE
No. of pens	5	5	5	5	—
No. of steers	35	35	35	35	—
Initial wt, kg	370.5	370.5	370.5	370.9	.23
Daily gain, kg[a]	1.79	1.87	1.79	1.87	.047
Daily feed, kg DM	9.68	9.68	9.77	9.50	.145
Gain/feed[b]	.184	.193	.183	.196	.0028
Liver abscesses, %	26	29	26	29	—
Diet net energy, Mcal/kg					
Maintenance[b]	2.19	2.26	2.17	2.30	.047
Gain[b]	1.51	1.57	1.50	1.60	.041

[a] Final weights were hot carcass weights adjusted to a 63.4% dress.

[b] 0 vs 4% yellow grease ($P \le .05$).

Table 4. Carcass traits of steers fed steam-flaked sorghum grain (SFSG) or corn (SFC) diets containing 0 or 4% yellow grease

	SFSG		SFC		
Item	0%	4%	0%	4%	SE
Hot carcass wt, kg	346	350	346	350	4.2
Dressing percentage	63.8	63.6	63.0	63.2	.61
Longissimus muscle area, cm^{2a}	80.0	82.6	83.9	85.8	1.42
Longissimus muscle area, cm^{2ab}	80.0	82.4	83.8	85.7	1.31
Backfat, cm	1.17	1.35	1.17	1.19	.058
Kidney, pelvic, and heart fat, %	2.40	2.61	2.33	2.41	.112
Yield grade[a]	3.07	3.21	2.87	2.84	.103
Marbling[c]	5.40	5.40	5.30	5.30	.130
Percentage Choice	83	74	83	80	—
Fat color[ade]	1.8	2.0	2.5	2.8	.10
Lean color[fg]	4.9	4.4	4.7	4.4	.20

[a] SFSG vs SFC ($P < .05$).
[b] Using hot carcass weight as a covariable.
[c] Slight^{50} = 4.5; small^{50} = 5.5.
[d] 0 vs 4% yellow grease ($P < .025$).
[e] Scale of 1 to 5; 1 = bleached white, 5 = bright yellow.
[f] Scale of 1 to 10; 1 = light cherry red; 10 = very dark red.
[g] 0 vs 4% yellow grease ($P < .08$).

based diets have been reported in a number of studies (Hatch et al., 1972; Johnson and McClure, 1972; Buchanan-Smith et al., 1974; Gramlich et al., 1990; Huffman et al., 1990). The reason, in part, that a positive response was obtained for YG addition to SFC in the present study may be the result of the low fat content (1.37% ether extract, dry basis) of the corn used. Average ether extract of corn is 4.2% (NRC, 1984).

Carcass Traits. Hot carcass weight, dressing percentage, percentage of kidney, pelvic, and heart fat, average marbling score, and percentage of carcasses grading Choice were not affected by treatment (Table 4). Steers fed SFC had a larger ($P < .05$) longissimus muscle area than steers fed SFSG, resulting in lower ($P < .05$) yield grades for SFC steers. This result is in contrast to those obtained in other studies comparing sorghum grain and corn (Maxson et al., 1973; Brethour, 1985), and a biological explanation is not readily apparent.

External fat cover was more yellow ($P < .001$) for steers fed SFC vs SFSG, and supplemental YG provided an additive effect ($P < .02$) on fat color. Increased yellow intensity, an undesirable trait, may be the result of pigments in corn and YG that are absorbed and deposited in the subcutaneous fat of steers. However, supplemental YG improved ($P < .05$) lean color. Although the magnitude of difference was small, consumer research is necessary to demonstrate whether these lean and subcutaneous fat color effects have an impact on desirability of the finished product.

Palatability Traits. Sensory and instrumental tenderness data are shown in Table 5. Samples from two carcasses were lost during the fabrication process at the packing plant. No treatment differences were detected for juiciness, flavor intensity,

Table 5. Effects of steam-flaked sorghum grain (SFSG) or corn (SFC) diets containing 0 or 4% yellow grease on sensory traits of beef longissimus muscle

	SFSG		SFC		
Item	0%	4%	0%	4%	SE
Juiciness	5.9	5.9	6.0	6.0	.08
Flavor intensity	6.2	6.1	6.1	6.2	.06
Off-flavor	7.8	7.8	7.7	7.8	.05
Myofibrillar tenderness	6.2	6.1	6.2	6.2	.07
Connective tissue	7.4	7.3	7.3	7.3	.06
Overall tenderness	6.5	6.3	6.4	6.4	.07
Warner-Bratzler peak shear force, kg	4.0	4.0	3.9	4.0	.14

[a] All sensory traits evaluated by a trained taste panel and scored on a scale of 1 to 8; 1 = extremely undesirable; 8 = extremely desirable.

Table 6. Effects of steam-flaked sorghum grain (SFSG) or corn (SFC) diets containing 0 or 4% yellow grease on chemical composition and cholesterol content of beef longissimus muscle

	SFSG		SFC		
Item	0%	4%	0%	4%	SE
No. of samples	20	20	19	19	—
No. Choice	15	12	17	15	—
Moisture, %	71.8	71.2	71.6	71.3	.27
Protein, %	22.0	22.6	22.4	22.1	.16
Fat, %	5.2	5.5	5.0	5.4	.29
Ash, %[a]	.82	.78	.94	.92	.026
Cholesterol, mg/g[b]	.49	.53	.49	.51	.008

[a] SFSG vs SFC ($P < .05$).
[b] 0 vs 4% yellow grease ($P < .05$).

off-flavor, myofibrillar tenderness, connective tissue amount, or overall tenderness. These results are important because they refute the contention by some that beef produced from sorghum grain is of lower quality than that produced from corn. No differences between treatments existed for peak shear force, confirming the sensory panel tenderness results.

Analytical Results. Neither grain type nor supplemental fat affected moisture, fat, or protein content of beef longissimus muscle (Table 6). Ash, however, was significantly higher ($P < .05$) in longissimus muscle of the SFC steers (.93%) than in that of the SFSG steers (.80%). This result was unexpected and confusing. One explanation is a higher contamination from rib bone fragment contamination for the SFC steers. Addition of 4% YG to the diet increased ($P < .05$) mean cholesterol content from .49 to .52 mg/g of wet tissue. Although statistically different, we feel that there is no biological significance in the cholesterol results. There was no relationship ($r = -.001$) in this study between cholesterol content and marbling score of longissimus muscle. These data are in concert with those of Rhee et al. (1982) and suggest that selection of higher quality (high marbling), trimmed cuts of beef will not elevate cholesterol intake relative to beef of lower quality.

Longissimus muscle from steers fed SFSG had a slightly lower ($P < .05$) concentration of linoleic (18:2) acid (3.2%) than muscle from SFC steers (3.8%; Table 7). Supplemental YG increased ($P < .05$) stearic acid (18:0) concentration. Although small in magnitude, this response is consistent with previous research with tallow and blended fats (Brandt and Anderson, 1990).

Implications

The energy value of sorghum grain can be elevated to that of corn by steam flaking. However, many factors, including degree of processing, berry size, and bulk density (bushel weight), can affect the utilization of energy in sorghum grain. In contrast to much previous research, supplemental fat improved gain efficiency of steers fed corn-based diets. The low fat content (1.37% ether extract) of the corn used in the study may have been a factor. The data clearly show that beef produced from sorghum grain is equal to that produced from corn.

Table 7. Fatty acid profile of longissimus muscle from steers fed steam-flaked sorghum grain (SFSG) or corn (SFC) diets containing 0 or 4% yellow grease

	SFSG		SFC		
Acid	0%	4%	0%	4%	SE
Myristic (14:0)	3.1	3.2	3.2	3.5	.10
Palmitic (16:0)	26.1	25.8	25.6	25.5	.28
Palmitoleic (16:1)	4.9	4.7	4.9	4.8	.11
Stearic (18:0)[b]	11.8	13.2	11.7	12.2	.28
Oleic (18:1)	45.1	43.5	45.6	45.4	.48
Linoleic (18:2)[c]	3.2	3.2	4.0	3.7	.16

[a] Percentage of total fatty acids.
[b] Fat effect ($P < .05$).
[c] Grain effect ($P < .05$).

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