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The effect of corn or sorghum dried distillers grains plus solubles on growth performance and carcass characteristics of cross-bred beef steers

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ABSTRACT

Sixty cross-bred steers (Angus ×; $n = 36$ and Charolais ×; $n = 24$) were used in a split-plot design to investigate the effects of feeding corn (*Zea mays*) or sorghum (*Sorghum bicolor*) dried distillers grains plus solubles in growing and finishing diets on growth performance and carcass traits. Steers were randomly assigned to one of three dietary treatments used in both feeding periods: a control diet containing soybean meal ($n = 20$; CON), a diet containing 200 g/kg (DM basis) corn dried distillers grains + solubles ($n = 20$; CDDGS) and a diet containing 200 g/kg (DM basis) sorghum dried distillers grains + solubles ($n = 20$; SDDGS). Steers were fed a corn silage (CS) based grower diet (~750/kg CS) for 56 d and then switched to a high grain finisher diet (150 g/kg CS). Feed intakes were measured using Insentec ($n = 48$) and Calan gate ($n = 12$) feeding systems. Animals were weighed every 28 d and slaughtered at an estimated backfat of 10 mm as estimated by ultrasound. Total trial average daily gain (ADG) was 1.56 kg/d ± 0.04 for CON, 1.54 kg/d ± 0.04 for CDDGS, and 1.51 kg/d ± 0.04 for SDDGS and did not differ ($P > 0.68$) between treatments. Dietary treatment did not affect ($P > 0.14$) dry matter intake (DMI) in the growing phase, although ADG was lower for SDDGS *vs.* CON ($P = 0.008$) and CDDGS ($P = 0.02$). There was a lower gain:feed in the growing phase for SDDGS *vs.* CDDGS ($P = 0.04$). In the finishing phase, inclusion of corn or sorghum DDGS did not affect ($P > 0.41$) ADG, DMI or G:F. However, fewer days on feed were required for SDDGS to reach the target backfat for slaughter than CDDGS ($P = 0.03$) and CON ($P = 0.05$). These results indicate that sorghum dried distillers grains plus solubles can be included at 200 g/kg inclusion level, similar to corn distillers grains plus solubles, in grower and finisher diets, without negatively influencing overall growth or carcass traits, although feeding SDDGS may result in reduced performance when corn silage based diets are fed and results in earlier fattening at a lighter body weight.

Abbreviations: ADF, acid detergent fibre; ADG, average daily gain; aNDF, neutral detergent fibre; BF, backfat; BW, body weight; CDDGS, corn dried distillers grains plus solubles; CS, corn silage; d, day; DDGS, dried distillers grains plus solubles; DM, dry matter; DMI, dry matter intake; G:F, gain:feed; HCW, hot carcass weight; LMA, longissimus muscle area; LSM, least squared means; PUN, plasma urea nitrogen; SD, standard deviation; SEM, standard error of the mean; SGGDS, sorghum dried distillers grains plus solubles; TMR, total mixed ration; USLMA, ultrasound measured longissimus muscle area.

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1. Introduction

Recent expansion in ethanol production in North America has caused an increase in the availability of distillers grains plus solubles as a feedstuff for livestock production. This has resulted in the need for additional research on the efficacy of using ethanol byproducts in livestock diets as compared to traditional feeds such as feed grains, oil-seed meals, and forages. With a large proportion of corn (*Zea mays*) being used for ethanol production, there is a need to further investigate other non-corn alternatives that are both suitable for the production of ethanol, are easily grown in North America and their by-products are suitable as livestock feedstuffs.

Dried distillers grains plus solubles (DDGS) are an excellent and potentially lower cost feedstuff than other more traditional feed sources to the cattle feeding industry. Much research has shown an improvement in growth by including either wet or dry corn distillers grains plus solubles in the diet over traditional high grain feedlot diets (Firkins et al., 1985; Larson et al., 1993; Vander Pol et al., 2009).

Grain sorghum (*Sorghum bicolor*) has been shown to be a viable alternative to corn for ethanol production, and although sorghum is a major crop produced in the United States, it is currently not utilized as extensively as corn in biofuel production (Wang et al., 2008). Efficacy of sorghum dried distillers grains plus solubles in the feedlot has been researched much less than corn distillers grains plus solubles. There is also a high degree of variability of results in the literature; some research has shown a favourable response with feeding the sorghum by-product (Al-Suwaiegh et al., 2002; Fanning et al., 1999), while others have shown that the feeding value of sorghum distillers grains (wet or dry) is lower than traditional feeds or corn distillers grains (Lodge et al., 1997; Vasconcelos et al., 2007; May et al., 2010).

The objective of this trial was to investigate the effects of including 200 g/kg (dry matter (DM) basis) corn or sorghum DDGS in forage-based grower diets and high grain finisher diets on growth performance (average daily gain (ADG), dry matter intake (DMI) and gain:feed (G:F)) and carcass characteristics in beef steers.

2. Materials and methods

2.1. Animal care and experimental design

This experiment followed the recommendations of the Canadian Council on Animal Care (1993) and met the approval of the University of Guelph Animal Care Committee. Sixty steers (average initial body weight (BW) ± SD = 298 ± 22 kg), consisting of red and black Angus sired (n = 36) and Charolais sired (n = 24) steers were used in a split-plot design, where barn served as the block (barn one and two). Steers were randomly assigned to pen and one of three dietary treatments continuously throughout the grower and finisher phases: control diets containing no DDGS (CON; n = 20), diets containing 200 g/kg (DM basis) corn DDGS (CDDGS; n = 20) and diets containing 200 g/kg (DM basis) sorghum DDGS (SDDGS; n = 20). Fresh water was available for *ad libitum* consumption at all times. Steers of each breed were equally distributed across dietary treatments, where each dietary treatment in barn one had 6 Charolais and 10 Angus sired steers (16 steers per pen) while each dietary treatment in barn two had 2 Charolais and 2 Angus sired steers (4 steers per pen). The experiment consisted of two feeding phases, a high forage (corn-silage) based grower diet followed by a high grain (high moisture corn) finisher diet (Table 1). Corn and sorghum grains used in this experiment were processed at the same ethanol plant and the wet distillers plus solubles was dried at the same facility. All diets were formulated to contain 145 g/kg and 137 g/kg CP for the grower and finisher phases, respectively, and met or exceeded the requirements for vitamins and minerals for beef cattle (NRC, 1996). Diets were fed as a total mixed diet once daily and contained a trace mineral and vitamin supplement with monensin. At the start and end of the trial, steers were weighed twice in the morning over 2 d. The grower diet was fed for 56 d and then steers were maintained on the same DDGS treatment while being gradually adjusted to the finisher diet over a four week period (28 d). Steers remained on the finisher diet for a minimum of 33 d before slaughter. Over the entire trial, animals were weighed every 28 d. Blood samples were obtained every 28 d via jugular venipuncture for later analysis of plasma metabolites. Dry matter intake was measured for individual animals using the Insentec feeding system (n = 48; Insentec BV., Marknesse, The Netherlands) in barn one as described by Mader et al. (2009) and using Calan gates (n = 12; American Calan, Inc., Northwood, NH, USA) in barn two.

2.2. Feed and sample analysis

Weekly total mixed ration (TMR) samples were collected and frozen at −20 °C for future analysis. Samples were later dried at 55 °C for 96 h to determine DM and then ground to pass through a 1 mm screen. All feed analysis was carried out at the Agri-Food Laboratories Inc. (Guelph, ON, Canada). Dry matter analysis was done in accordance with the Association of Official Analytical Chemists guidelines (1990, Method 930.15.). Crude protein concentration was determined by multiplying 6.25 by percent dietary nitrogen as determined by Leco Nitrogen analyzer (Leco Corporation, St. Joseph, MI, USA). Acid detergent fibre (expressed inclusive of residual ash; ADF) and aNDF (assayed with heat stable amylase and sodium sulphite, and expressed inclusive of residual ash) were determined using the methods of Robertson and Van Soest (1981) using an Ankom fibre analyzer (Ankom Technology Corp., Fairport, NY, USA).

Blood samples were centrifuged at 3000 × g for 20 min and plasma was separated and then frozen at −20 °C until analyzed. Plasma urea nitrogen (PUN; Sampson et al., 1980) and glucose (Trinder, 1969) concentrations were analyzed by

Table 1
Diet composition and analyses.

	Dietary treatment[a]					
	CON grower	CDDGS grower	SDDGS grower	CON finisher	CDDGS finisher	SDDGS finisher
Ingredient (g/kg, DM basis)						
Corn silage	762	752	756	150	150	150
High moisture corn	–	–	–	688	596	600
Soybean meal	149	–	–	113	–	–
CDDGS	–	200	–	–	200	–
SDDGS	–	–	200	–	–	200
Ground corn	51	–	–	–	–	–
Urea	–	10	6	–	4	–
Mineral premix[b]	15	15	15	27	27	27
Vitamin/monensin premix[c]	23	23	23	23	23	23
Analysis[d]						
DM, g/kg	415	416	425	606	610	618
CP, g/kg DM	147	145	153	141	135	141
ADF, g/kg DM	179	209	227	59	65	93
aNDF, g/kg DM	310	341	344	129	143	165
NEm, MJ/kg DM[e]	7.5	7.4	7.4	8.1	8.0	8.0
NEg, MJ/kg DM[e]	4.5	4.4	4.4	5.1	5.0	5.0

ADF = acid detergent fibre; aNDF = neutral detergent fibre; CDDGS = corn distillers grains plus solubles; CP = crude protein; DM = dry matter; NE_g = Net energy for gain; NE_m = Net energy for maintenance; SDDGS = Sorghum distillers grains plus solubles.

[a] Dietary treatment: CON = Control dietary treatment; CDDGS = Corn dried distillers grains plus solubles (200 g/kg inclusion level); SDDGS = Sorghum dried distillers grains plus solubles (200 g/kg inclusion level).

[b] Contains 795 g/kg limestone, 160 g/kg salt, 45 g/kg CF Beef Cattle trace mineral mix (contains 153,013 mg/kg Zn, 122,445 mg/kg Mn, 30,598 mg/kg Cu, 27,100 mg/kg Fe, 368 mg/kg Co, 1,531 mg/kg I; DM basis).

[c] Contains 936.3 g/kg dry ground corn, 56.6 g/kg vitamin premix (4,400,000 IU/kg vitamin A, 1,100,000 IU/kg vitamin D, and 7700 IU/kg vitamin E), 7.1 g/kg monensin premix (200 g monensin/kg; DM basis).

[d] Average of weekly diet samples.

[e] Calculated according to Weiss et al. (1992) and NRC (1996).

spectrophotometry using the PowerWave XS microplate spectrophotometer (BioTek Instruments Inc., Winooski, VT, USA) and commercially available kits from Teco Diagnostics (Anaheim, CA, USA).

2.3. Carcass measurements

Steers were sent to slaughter based on attaining an estimated ultrasound backfat (BF; between the 12th and 13th rib) of 10 mm as determined using ultrasound (Aloka SSD-500 ultrasound unit; Corometrics Medical Systems, Wallingford, CT, USA). Cattle approaching 10 mm backfat were ultrasounded weekly until they reached approximately 10 mm of backfat and were sent to slaughter the following week. Steers remaining on feed on or after d 264 were sent to slaughter that week or the following week regardless of BF depth ($n = 18$) which resulted in 7 steers having a BF thickness of less than 8 mm when sent to slaughter. Steers were slaughtered at the University of Guelph Meat Laboratory. A final BW was obtained by weighing on two consecutive days, 24 h prior to and the morning of slaughter. Hot carcass weight, grade fat (minimum fat depth over the last quadrant of the longissumus muscle), longissimus muscle area (LMA), subjective marbling score, and lean, fat and bone yield percentages (based on 9th to 12th rib section dissections as an indicator of body composition) were determined as previously described (Laborde et al., 2002; Mandell et al., 1997; Mader et al., 2009). All carcasses were graded by Canadian Beef Grading Agency graders according to Livestock and Poultry Carcass Grading Regulations (Agriculture Canada, 1992) to determine carcass grade and yield characteristics. Liver abscess scores were recorded as outlined by Brink et al. (1990) using the following scoring system: no abscess (O), one or two small (less than ~2.5 cm in diameter) abscesses or abscess scars (A−), two to four active abscesses under 2.5 cm in diameter or one larger (>2.5 cm in diameter) active abscess (A), more than 5 active small abscesses or more than one large active abscess (A+). Liver abscess scores were converted into a numerical score where none = 0, A− = 1, A = 2 and A+ = 3. Weights of liver, heart, kidney, pancreas and lungs (including trachea) were also obtained at slaughter.

2.4. Data analysis

Average daily gains and G:F were calculated for the grower period (d 0 to d 56), finisher period (d 84 to each individual animal's slaughter date) and total trial (including the transition period). Days on feed is reported for the finishing period only and does not include the 28 d transition period. In barn one (Insentec feeding system), average daily feed intake data were calculated using methods described by Kelly et al. (2009), where any negative or zero value feeding events were removed, daily intake values that were more than three standard deviations from the individual animal's mean intake were replaced

Table 2
The influence of corn or sorghum dried distillers grains plus solubles on growth performance of steers.

Item	Dietary treatment[d]				
	CON	CDDGS	SDDGS	SEM	Pr>F
Overall experiment					
Final BW, kg	606.0[ab]	617.8[a]	571.4[b]	4.84	0.04
Days on feed[e], d	198.0[a]	202.5[a]	178.9[b]	2.21	0.03
ADG, kg/d	1.56	1.54	1.51	0.04	0.68
DMI, kg/d	8.25	8.45	8.34	0.223	0.82
Gain:feed	0.187	0.147	0.189	0.007	0.09
Grower period					
Final BW, kg	382.0	385.0	371.7	4.50	0.29
Days on feed, d	56	56	56	–	–
ADG, kg/d	1.42[a]	1.34[a]	1.21[b]	0.01	0.009
DMI, kg/d	7.2	6.7	6.6	0.13	0.13
Gain:feed	0.197[ab]	0.201[a]	0.184[b]	0.002	0.04
Finishing period[f]					
Final BW, kg	606.0[ab]	617.8[a]	571.4[b]	4.84	0.04
Days, on feed, d	114.0[a]	118.5[a]	94.6[b]	2.21	0.03
ADG, kg/d	1.70	1.79	1.70	0.09	0.75
DMI, kg/d	9.2	8.9	9.1	0.19	0.57
Gain:feed	0.19	0.21	0.19	0.009	0.40

ADG = Average Daily Gain; BW = Body weight; DMI = dry matter intake.
[a–c]Values reported are LSM and SEM ($n = 20$). Means in row not sharing the same superscript letter differ significantly ($P<0.05$).
[d] Dietary treatment: CON = Control dietary treatment; CDDGS = Corn dried distillers grains plus solubles (200 g/kg inclusion level); SDDGS = Sorghum dried distillers grains plus solubles (200 g/kg inclusion level).
[e] Number of days on feed for total trial (56 d grower period, 28 d transition and finisher period).
[f] Does not include 28 d adaptation period.

with the individual animal's mean intake for that period and any days where the system was not functioning were removed from the data set. In barn two (Calan gate system), orts were weighed once a week and average daily feed intake calculated from weekly feed records.

Data were analyzed as a standard split-plot design as outlined by Kuehl (2000) and the model included the effect of dietary treatment (main plot), breed (sub-plot), block (the barn), breed x dietary treatment interaction and the random effect of pen nested within block and treatment. Data were analyzed using PROC GLM in SAS (2008). A Tukey–Kramer test was used to make all pair-wise comparisons and differences were considered significant at $P \leq 0.05$. Data are presented with main effect P-values in tables and Tukey–Kramer P-values in text. Because steers remaining on trial after d 264 did not reach the target ultrasound backfat of 10 mm before being slaughtered, grade fat was initially added as a covariate in the model for total average daily gain measurements and carcass traits; however, the covariate was only significant ($P \leq 0.05$) for lean yield, and consequently removed from the model for all traits except lean yield.

3. Results

Breed x dietary treatment interactions initially indicated differences (P=0.04) for finisher period DMI only. However, further analysis of finisher period DMI using the Tukey–Kramer test indicated no differences (P>0.55) between dietary treatments. There were no ($P \geq 0.05$) breed x treatment interactions observed for other traits (data not shown).

Final BW was greater (P=0.04) in CDDGS steers than SDDGS but not greater (P=0.07) than steers fed CON (Table 2). Steers fed CON did not differ (P=0.38) in final BW from steers fed SDDGS. Steers fed SDDGS also spent fewer days on feed in the finisher period to reach the target slaughter BF than CON and CDDGS (P=0.05 and P=0.03, respectively). The total trial period ADG, DMI and G:F did not differ (P>0.09) across dietary treatments. Average daily gain in the grower phase, however, was greater for steers fed CON and CDDGS than steers fed SDDGS (P=0.008 and P=0.02, respectively) while DMI did not differ (P>0.14) between dietary treatments. This resulted in lower (P=0.04) G:F for SDDGS than CDDGS. Steers fed CON did not differ in G:F from SDDGS (P=0.07) and CDDGS (P=0.44). There were no differences (P>0.41) in ADG, DMI or G:F between dietary treatment groups for the finishing period.

Plasma urea N concentrations did not differ on d 1 of the experiment (P>0.43; Table 3). Plasma urea N concentrations on d 56 were lower and change in urea N concentration from d 1 until d 56 were more negative in steers fed SDDGS than CON, but not different (P=0.09) than CDDGS. Changes in PUN concentrations did not differ (P=0.29) between CON and CDDGS. Plasma urea N concentrations on d 84 and d112 as well as change in urea N concentration from d 84 until d 112 did not differ between treatments (P>0.17). Plasma glucose concentrations on d1, d 56, d 84, and d 112, as well as change in concentration from d 1 until d 56 and d 84 until d 112 did not differ (P>0.15) between treatments.

Dressing percentage was similar (P>0.35) across dietary treatments (Table 4). Hot carcass weight was lower (P=0.04) in steers fed SDDGS than CDDGS but not different (P=0.06) from CON. Hot carcass weight did not differ (P=0.63) between steers fed CON and CDDGS (Table 4). There were no differences (P>0.48) in grade fat, LMA, and marbling score between

Table 3
The influence of corn or sorghum dried distillers grains plus solubles on steer weight, blood metabolites, and ultrasound measures of backfat and longissimus muscle area.

Item	Dietary treatment[d]				
	CON	CDDGS	SDDGS	SEM	P>F
Plasma urea N, mg/dL					
Day 1	8.2	7.8	7.9	0.18	0.43
Day 56	10.1[a]	8.6[ab]	5.5[b]	0.52	0.05
Change over grower period[e]	1.9[a]	0.8[ab]	−2.3[b]	0.42	0.04
Day 84	9.4	7.4	7.0	0.61	0.18
Day 112	6.7	7.0	6.6	0.58	0.90
Change in finisher[f]	−2.7	−0.4	−0.4	0.65	0.18
Plasma glucose, mg/dL					
Day 1	75.8	89.0	94.3	4.12	0.16
Day 56	83.2	87.3	91.2	2.44	0.27
Change over grower period	7.5	−1.7	−3.1	4.19	0.35
Day 84	91.5	89.4	101.5	5.09	0.38
Day 112	80.2	79.8	89.2	2.57	0.19
Change over finisher period	4.0	−9.2	−5.1	6.44	0.77

[a–c]Values reported are LSM and SEM ($n=20$). Means in row not sharing the same superscript letter differ (P<0.05).
[d] Dietary treatment: CON = Control dietary treatment; CDDGS = Corn dried distillers grains plus solubles (200 g/kg inclusion level); SDDGS = Sorghum dried distillers grains plus solubles (200 g/kg inclusion level).
[e] Change is the difference between the d 56 value and the d 0 value.
[f] Change is the difference between the d 112 value and the d 84 value.

Table 4
The influence of corn or sorghum dried distillers grains plus solubles on carcass characteristics, rib dissection and body composition.

Item	Dietary treatment[d]				
	CON	CDDGS	SDDGS	SEM	Pr > F
Dressing yield, g/kg	590	586	584	2.3	0.36
Hot carcass weight, kg	359.3[ab]	363.8[a]	335.4[b]	3.12	0.04
Grade fat, mm	8.6	7.8	8.4	0.36	0.48
Longissimus muscle area, cm^2	99.2	99.1	95.0	3.16	0.64
Marbling score[e]	5.0	5.0	5.0	0.09	0.95
Lean yield[f]	60.4	60.5	60.2	0.38	0.82
Rib sample weight, kg	4.2	4.3	4.0	0.07	0.25
Lean, g/kg of rib weight	566	567	578	2.5	0.14
Bone, g/kg of rib weight	194	200	196	6.0	0.80
Total fat, g/kg of rib weight	240	233	227	5.8	0.45
Body cavity fat, g/kg of total fat	184	163	171	13.5	0.61
Subcutaneous fat, g/kg of total fat	434	400	438	14.8	0.33
Intertermuscular fat, g/kg of total fat	382	437	391	25.1	0.41

[a–c]Values reported are LSM and SEM ($n=20$). Means in row not sharing the same superscript letter differ significantly (P<0.05).
[d] Dietary treatment: CON = Control dietary treatment; CDDGS = Corn dried distillers grains plus solubles (200 g/kg inclusion level); SDDGS = Sorghum dried distillers grains plus solubles (200 g/kg inclusion level).
[e] Longissimus muscle scored subjectively for marbling using a 10-point scale (10 = devoid, 9 = practically devoid, 8 = traces, 7 = slight, 6 = small, 5 = modest, 4 = moderate, 3 = slightly abundant, 2 = moderately abundant, 1 = abundant).
[f] Grade fat included as a covariate in the model (P<0.001) for lean yield.

dietary treatments. Lean yield also was not different (P>0.80) between any of the treatment groups. There was no difference (P>0.23) in dissected weight of rib between dietary treatments. There were no differences (P>0.18) observed between dietary treatment groups for lean as a percentage of rib weight, bone weight as a percentage of rib weight, and total fat as a percentage of rib weight. There were also no differences (P>0.41) in body fat as a percentage of total fat, subcutaneous fat as a percentage of total fat, or intermuscular fat as a percentage of total fat between any of the treatment groups.

Liver abscess scores were not influenced (P>0.67) by dietary treatment (Table 5). Steers fed SDDGS had greater (P=0.04) liver weights per kg of BW than CDDGS but did not differ (P=0.31) from CON and CDDGS was not different (P=0.08) for liver weight per kg of BW from CON. Kidney, heart, lung and pancreas weights (relative to BW), were not different between any of the dietary treatments ($P \geq 0.09$) between treatment groups.

4. Discussion

The increase in grain-based ethanol production has created a need to seek alternative feed sources to traditional corn based feedlot diets. Using by-products from the ethanol industry is a good alternative feed source for feeding cattle; however

Table 5
The influence of corn or sorghum dried distillers grains plus solubles on liver abscess score and organ weight.

	Dietary treatment[d]				
	CON	CDDGS	SDDGS	SEM	Pr > F
Liver abscess score[e]	1.0	0.9	0.4	0.38	0.56
Liver weight/BW, g/kg	12.36[ab]	12.16[a]	12.44[b]	0.03	0.04
Kidney weight/BW, g/kg	1.8	2.3	1.9	0.25	0.53
Heart weight/BW, g/kg	4.0	4.9	4.0	0.14	0.07
Lung weight/BW, g/kg	11.0	10.8	11.0	0.55	0.98
Pancreas weight/BW, g/kg	0.9	0.8	0.8	0.04	0.48

BW = body weight.
[a–c]Values reported are LSM and SEM (n = 20). Means in row not sharing the same superscript letter differ significantly (P<0.05).
[d] Dietary treatment: CON = Control dietary treatment; CDDGS = Corn dried distillers grains plus solubles (200 g/kg inclusion level); SDDGS = Sorghum dried distillers grains plus solubles (200 g/kg inclusion level).
[e] Presence of liver abscesses were scored using a 3 point scale (no abscess (O), one or two small (less than ~2.5 cm in diameter) abscesses or abscess scars (1), two to four active abscesses under 2.5 cm in diameter or one larger (>2.5 cm in diameter) active abscess (2), more than 5 active small abscesses or more than one large active abscess (3)).

the effectiveness of non-corn based ethanol by-products, like sorghum, need to be further investigated, especially in regions of North America where new varieties of sorghum, more suitable to a temperate climate, are being developed for use as livestock feeds and alternatives to corn in ethanol production.

While final BW and HCW were lower in steers fed SDDGS *versus* CDDGS, this is likely a result of the fewer days on feed for SDDGS steers to attain the target slaughter BF thickness, and not a direct response of dietary treatment. This is further supported by the fact that ADG and G:F did not differ between treatments over the finishing phase or over the overall experiment. The use of constant backfat endpoint in the present study may be responsible for the absence of dietary treatment differences in carcass traits and body composition. Klopfenstein et al. (2000) found similar carcass traits for 534 serially slaughtered cattle slaughtered at similar BF thickness.

There were no differences between any dietary treatment in total trial period ADG, indicating that sorghum DDGS may be an acceptable alternative to corn DDGS or a control diet containing soybean meal, although cattle fed SDDGS reached the back-fat endpoint earlier and at a lighter weight. There is variation in the results of past research comparing sorghum and corn distillers grains plus solubles to traditional feedlot diets. Fanning et al. (1999) found that steers fed sorghum distillers grains had greater fat thickness and DM intake than corn distillers grains; however, dressing percentages, LMA, marbling score and liver abscess score were not affected by dietary treatment. Fanning et al. (1999) reported increased fattening in the steers fed sorghum distillers grains, and similarities between corn and sorghum distillers grains for other carcass characteristics which are similar to the results for the present study. Al-Suwaiegh et al. (2002) found that using 300 g/kg of either wet corn distillers grains or 300 g/kg wet sorghum distillers grains increased hot carcass weights, fat thickness, and yield grades over a dried rolled corn-based control diet. The present study supports previous research that use of sorghum distillers grains in the finisher diet increased fattening with reduced time on feed to reach the 10 mm BF endpoint. In contrast, Vasconcelos et al. (2007) found that feeding increasing levels of sorghum wet distillers grains (0, 50, 100, 150 g/kg of a steam-flaked corn-based diet) in the diet decreased performance, carcass fat thickness and HCW over feeding a control diet.

In the grower period, steers fed SDDGS did not perform as well as CDDGS and CON, since ADG was lower in steers fed SDDGS than CDDGS and CON and G:F was lower in SDDGS than CDDGS. Since there was also an observed decrease in PUN in steers fed SDDGS compared to CON, it is possible that this reduction in growth in the grower period was due to differences in dietary protein characteristics. Waller et al. (1980) investigated the feeding value of different ethanol by-products as a protein source and determined that the relative feeding value was lowest for sorghum DDGS. The comparative protein efficiency value (defined as daily gain above urea control divided by daily supplemental protein fed) of sorghum (milo) dried distillers grains, sorghum (milo) DDGS, corn dried distillers grains, corn DDGS, and soybean meal over urea was 1500, 1300, 2000, and 180 g/kg, respectively. Waller et al. (1980) suggested that the varying protein efficiency values are a result of feedstuff differences in protein solubility characteristics. Lodge et al. (1997) investigated the feeding values of both wet sorghum distillers grains, wet sorghum distillers grains plus solubles and dry sorghum distillers grains plus solubles and found that when the wet sorghum distillers grains was compared to wet corn distillers grains, corn had higher true nitrogen and apparent nitrogen and organic matter digestibility than sorghum wet distillers grains and sorghum DDGS had the lowest NE_g content than all other treatments. Wu and Sexson (1985) reported that the solubility of sorghum distillers grains is much lower than that of corn distillers grains. In a review, Duodo et al. (2003) also reported fundamental differences in the protein structure between sorghum grain and corn, especially when wet cooked, which can have a major impact on protein digestibility. They suggest that there is greater hydrophobicity in sorghum kafrin proteins than in corn zein proteins, which results in increased crosslinking in the α and β kafrins, decreasing overall protein digestibility. Since the process of ethanol fermentation involves a step which is similar to wet cooking, it is likely that overall protein digestibility may have been negatively affected resulting in lower PUN concentrations in SDDGS. Since the SDDGS diet contained more CP than the CON and CDDGS diets, differences in protein quality and digestibility characteristics among the dietary treatments may be responsible for lower growth performance in cattle fed SDDGS. The reason that we did not see a similar response during the finishing phase could be the result of differences in ruminal protein utilization when forage- or grain-based diets are fed, or it could be due to differences in overall protein intake and quality relative to protein requirements at different phases of growth. Additionally, effects observed during the grower period could have influenced subsequent finishing performance. However, further research on the protein digestibility of corn and sorghum distillers grains is needed.

In the finisher period, ADG did not differ between treatments, yet steers fed SDDGS spent fewer days on feed to reach the target slaughter BF than CON and CDDGS. It is possible that earlier fattening observed in the SDDGS group resulted from the effects of reduced growth in the grower period. If growth was limited by protein structure in the grower period, the potential final mature size may have been reduced with SDDGS steers fattening at a lower BW after being switched to a higher plane of nutrition in the finisher diets (Owens et al., 1993). Liver weight (g/kg BW basis) was greater for steers fed SDDGS than that observed in CDDGS which may be an indication of compensatory growth, although no treatment differences in finisher period or overall ADG were observed in this experiment. Research by Yambayamba et al. (1996) indicated that liver growth was accelerated in beef heifers that were previously feed restricted and then fed energy dense diets, to induce compensatory gain. Further research is needed to determine if the differences between grower and finisher performance is mutually exclusive or dependant on the preceding grower or transition period treatment.

5. Conclusion

Results of this study indicate that steers fed SDDGS at 200 g/kg diet DM did not perform as well as CDDGS or CON when fed a high forage grower diet. However, growth performance generally did not differ between treatment groups over the entire feeding period composed of a corn-silage based grower period and a high-corn finishing period. This data suggests that feeding sorghum DDGS in the grower phase may result in premature fattening, allowing steers to gain BF at a smaller BW. Further research is needed to determine the optimum inclusion level of sorghum DDGS in the diet, determine the effects of sorghum DDGS in a one phase feeding regime (grower or finisher only), as well as to better understand the effects of sorghum DDGS on rumen metabolism and protein digestibility.

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