SHORT COMMUNICATION: Impact of low- and medium-oil corn dried distillers' grains plus solubles on growth performance of feedlot cattle

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Abstract

During backgrounding, low-oil dried corn distillers' grains plus solubles (LO-DDGS) resulted in higher DM intake (P=0.002) and increased ADG (*P*=0.03) in steers compared to medium-oil (MO) DDGS. Inclusion of 20% DDGS tended (*P*=0.06) to increase ADG compared to 10% DDGS. During finishing, MO-DDGS improved (*P*=0.03) feed efficiency compared to LO-DDGS.

Key words: beef, carcass quality, corn dried distillers' grains plus solubles, efficiency

Abbreviations: ADF, acid detergent fibre; **ADG**, average daily gain; **CDO**, corn distillers' oil; **CP**, crude protein; **DDGS**, corn dried distillers' grains with solubles; **DM**, dry matter; **DMI**, dry matter intake; **EE**, ether extract; **G:F**, Gain:Feed; **LO-DDGS**, low-oil corn dried distillers' grains plus solubles; **MO-DDGS,** medium-oil corn dried distillers' grains plus solubles; **NDF**, neutral detergent fibre; **NEg**, net energy for gain; **NEm**, net energy for maintenance; **OM**, organic matter

Introduction

Due to the low crude protein (CP) content of corn silage [8.2±1.07% dry matter (DM) basis; NASEM, 2016] supplemental CP is needed to maintain optimum growth rate in cattle fed corn silage-barley grain based diets. Over the last 20 years, expansion of the North American grain ethanol industry has increased the supply dried distillers' grains plus solubles (DDGS) for feedlot cattle. Consequently, DDGS is the most common protein supplement in the North American beef industry (Renewable Fuels Association, 2015). As starch is almost completely removed from corn during ethanol fermentation nutrients in DDGS are concentrated nearly three-fold.

Corn DDGS has a relatively high oil content (10.7±2.05% DM basis; NASEM, 2016) which can be used to produce biodiesel and as a result ethanol producers are increasingly using enhanced oil extraction technologies. By 2014, approximately 85% of dry mills in the U.S. used enhanced extraction techniques and produced approximately 1.1 billion kg of corn oil (Renewable Fuels Association, 2015). . Differences in corn oil extraction technologies lead to variation in DDGS composition. Solvent-extraction of corn oil typically produces DDGS with an oil content of less than 3.0% (DM basis; Saunders and Rosentrater, 2009), whereas ethanol plants that use mechanical extraction produce DDGS with an oil content of 6.0 to 9.0% (DM basis; He et al., 2014).

Feeding conventional corn DDGS (>10% EE; DM basis) to ruminants generally has a positive impact on growth performance, a finding which can partly be attributed to its higher energy content than cereal grains (Klopfenstein et al., 2008). He et al. (2014) found that replacement of 30% of barley grain DM in a beef finishing feedlot diet with low-oil corn DDGS (7.1%) decreased feed efficiency.   This study was designed to examine the effect of LO-DDGS, 5.6% EE or MO-DDGS, 8.3% EE on feed intake, growth performance, and carcass quality of feedlot steers fed corn silage-barley grain diets.

Materials and Methods

All procedures and protocols were reviewed and approved by the Lethbridge Research Centre Animal Care Committee as per the guidelines of the Canadian Council on Animal Care.

Animals, Experimental Design, and Diets

A combined growing (84 d) and finishing (112 d) study was conducted using 160 Angus crossbreed steers [307 ± 21.1 kg initial live body weight (BW)]. Upon arrival, steers were treated with Ultrabac 7/Somubac, (Zoetis Canada Inc., Kirkland, Quebec, Canada), Express FP5 (Boehringer Ingelheim Ltd. Burlington, Ontario, Canada) and Biomectin Pour-on (Merial Canada Inc., Baie D'Urfé, Quebec, Canada). Steers were implanted with Component TE-100 (100 mg trenbolone acetate, 10 mg estradiol and 29 mg tylosin tartrate; Elanco Animal Health, Guelph, Ontario, Canada) on d 1 of the experiment and were re-implanted with Component TE-S (120 mg trenbolone acetate, 24 mg estradiol and 29 mg tylosin tartrate; Elanco Animal Health, Guelph, Ontario, Canada) 90 d before the end of the finishing experiment.

Steers were blocked by weight and randomly assigned to 1 of 16 pens (n = 10 steers per pen). Each pen was allocated to 1 of 4 treatments (Table 1; 4 pens/treatment) consisting of two levels of oil iLO-DDGS (5.6%), POET Biorefining, Groton, South Dakota, U.S. or MO-DDGS (8.3%), Blue Flint Ethanol; Washburn, North Dakota, U.S and two DDGS inclusion levels 10% or 20% (DM basis) during the growing period and 5% or 10% (DM basis) during finishing. Pens (17 m × 12.7 m; with 1.2 m bunk space per head) were equipped with automatic waters and separated by porosity fences on two sides. After completion of the growing phase steers were transitioned to high-grain diets over 21 d. The DDGS was substituted for barley grain which was processed to an index (vol. weight after processing/ vol. weight before processing × 100) of 80% ± 3%.

Growth Performance and Carcass Measurements

Diets were prepared daily using a Beck 220 feed truck (Beck Implement Inc., Elgin, MN). Steers were fed once daily at 1000 h to appetite targeting <5% orts. Diets were balanced according to the recommendations of NASEM (2016) for growing and finishing feedlot cattle. Monensin sodium was included in all diets at 25 mg/kg (diet DM). Urea was added to diets with lower levels of DDGS to make them isonitrogenous. The quantity of feed offered was recorded daily and representative samples were collected weekly. Pen dry matter intake (DMI) was calculated as the difference between the amount of feed DM offered and refused. Steers were weighed before feeding on 2 consecutive days at the start and end of the growing and finishing phases, and every 21 and 28 d, respectively. Weights were reported as shrunk weight (BW × 0.96) and average daily gain (ADG) was calculated by dividing shrunk BW gain (final BW -- initial BW) by days on feed. Carcass adjusted ADG was calculated as: Carcass adjusted ADG = [(Carcass weight/0.60) – initial BW] / days on feed. Feed conversion efficiency (Gain:Feed) was calculated by dividing ADG by DMI. Net energy gain of the diets was calculated based on growth performance as described by Ribeiro et al. (2016).

Steers were slaughtered at Cargill (High River, AB) and hot carcass weight (with kidneys removed), dressing percentage, back fat thickness, rib eye area, lean meat yield and quality grade determined. Liver abscess scores were determined according to the Elanco system.

Feed Sampling and Chemical Analysis

Diets, orts, and ingredients were sampled weekly, oven dried at 55°C for 72 h. Feed samples were composited by weigh period (21 d growing phase, 28 d finishing phase), ground through a 1 mm (Wiley mill; Arthur H. Thomas, Philadelphia, PA) and analytical DM was determined by drying at 135°C for 2 h (AOAC, 2005; method 930.15). Neutral detergent fibre (NDF) and acid detergent fibre (ADF), both expressed inclusive of residual ash were using amylase and sodium sulfite for the NDF analysis. Ether extract (EE) was determined according to AOAC (2005; method 2003.06). For the measurement of CP (N × 6.25) and starch, sub-samples (5 g) were further ground with a ball grinder (Retsch MM 400; Retsch Inc., Newtown, PA). Nitrogen was quantified by flash combustion with gas chromatography and thermal conductivity detection (Carlo Erba Instruments, Milan, Italy). Starch content of diets and diet ingredients was determined by enzymatic hydrolysis of α-linked glucose polymers.

Statistical analyses

Data were analyzed as completely randomized design with a 2 × 2 factorial treatment structure using the MIXED model procedure of SAS (SAS Inst. Inc., Cary, NC). Residual DDGS oil content, dietary inclusion level and their interaction were included as fixed effects. Pen was considered the experimental unit for DMI and growth performance parameters. Individual steer was the experimental unit for carcass measurements and liver scores. Initial BW was included as a covariate when significant. The GLIMMIX procedure was used to analyze liver scores and quality grade (AA, AAA or Prime). Significance was declared at $P < 0.05$ with trends discussed at $0.05 \leq P \leq 0.10$.

Results and Discussion

The chemical composition of LO-DDGS was 94.3±0.12% OM, 5.0±0.38% starch, 34.5±1.19% CP, 29.2±1.19% NDF, 7.7±0.41% ADF, 5.6±0.43% EE (Mean±SD, DM), while MO-DDGS averaged 95.2±0.07% OM, 2.5±0.35% starch, 32.4±1.05% CP, 36.9±1.47% NDF, 11.3±0.88% ADF, 8.3±0.22% EE (Mean±SD, DM). The level of oil in MO-DDGS was 2.7% higher than LO-DDGS. The calculated NEm and NEg were 3.3% and 3.4% lower respectively, for LO-DDGS than MO-DDGS (NASEM, 2016). Feeding LO-DDGS diets during the growing period increased DMI (P=0.002) and ADG (P=0.03) of steers as compared to the MO-DDGS diets (Table 2). Steers offered 20% DDGS diets tended to have higher ADG ($P = 0.06$) compared to those fed 10% DDGS diets. Feed efficiency and NEg of the diet were not affected ($P > 0.10$) by diet. Increased ADG in response to LO-DDGS in the growing phase was a result of increased DMI as feed efficiency was not improved. The numerically lower NEg associated with small changes in the composition of LO-DDGS as compared to MO-DDGS, suggests that the higher DMI may be related to the slightly higher CP content (15.8% vs. 14.5%) and lower energy content of LO-DDGS diets, with steers compensating by eating more. An increase in DMI in the first 42 d of the backgrounding period was also observed by Galyean et al. (1993) when diet CP concentration increased from 14% to 16%.

The DMI and ADG during the finishing period were not affected by DDGS type or inclusion level ($P > 0.10$; Table 3). However, feeding MO-DDGS to finishing steers improved Gain:Feed as compared to LO-DDGS (P=0.03). Consequently, a tendency ($P = 0.09$) for higher NEg content of the diet was observed for MO-DDGS (1.34 Mcal/kg) as compared to LO-DDGS (1.28 Mcal/kg). Although the differences in fat content among diets were small, improved feed efficiency in response to MO-DDGS coincided with its higher energy content. Similarly, Walter et al. (2010) observed improved feed efficiency in finishing steers as dietary fat increased as the level of corn DDGS was increased. In contrast, increasing the fat content of finishing diets by increasing inclusion of low oil corn DDGS decreased feed efficiency (He et al. 2014). The similarity in predicted NEg from TDN according to NASEM (2016) for LO- and MO-DDGS finishing diets (1.33 Mcal kg^{-1}, Table 1), contrasts with the observed tendency for higher NEg in MO-DDGS compared to LO-DDGS finishing diets (1.33 vs. 1.28 Mcal kg^{-1}, Table 3). Different feed efficiency responses between studies evaluating corn DDGS and in predicted vs. achieved NEg seems to depend on the chemical composition of the diet, and variation in DDGS quality due to differences in drying temperature or the amount of added solubles. Other factors such as the concentration of DDGS in the diet and interactions of DDGS with other dietary components can also influence its NEg value (Klopfenstein et al., 2008). Plant and sometimes batch specific factors can not only impact the oil content of DDGS, but also its fibre and protein digestibility. Interestingly, no differences ($P > 0.10$) in DMI, ADG, Gain:Feed or NEg were observed when finishing steers were fed 10% or 5% DDGS diets supplemented with urea (DM basis). This indicates that LO-DDGS and MO-DDGS could partially replace dry rolled barley plus urea without losses in ADG or feed efficiency in finishing diets.

Hot carcass weight, dressing percentage, back fat thickness, rib eye area, quality grades, lean meat yield and liver abscess scores were not affected ($P > 0.10$) by DDGS source or inclusion level (Table 3). He et al. (2014) also reported that replacing 30% of the barley grain with LO-DDGS in a finishing diet did not affect the carcass traits of steers. It is interesting to note that numerically, carcasses of steers fed MO-DDGS were classified as Prime more than twice as often compared to LO-DDGS diets (7.8% vs. 2.6%). Compared to MO-DDGS, feeding LO-DDGS during backgrounding resulted in higher DMI and increased ADG, but did not improve feed efficiency. In finishing steers, MO-DDGS improved feed efficiency as compared to LO-DDGS. Thus, DDGS with lower oil content have higher feed value in growing diets while DDGS with higher oil content have greater feed value in finishing diets.

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Table 1. Ingredients and chemical composition (Mean±SD, *n* = 4) of experimental diets.

Item	Backgrounding Diets				Finishing Diets			
	10% LO-DDGS	20% LO-DDGS	10% MO-DDGS	20% MO-DDGS	5% LO-DDGS	10% LO-DDGS	5% MO-DDGS	10% MO-DDGS
Diet ingredient (% of DM)								
Corn silage	60.00	60.00	60.00	60.00	10.00	10.00	10.00	10.00
Barley grain, dry-rolled	24.30	15.00	24.30	15.00	79.65	75.00	79.65	75.00
Low-oil DDGS[a]	10.00	20.00	-	-	5.00	10.00	-	-
Medium-oil DDGS[b]	-	-	10.00	20.00	-	-	5.00	10.00
Supplement[c]	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Urea	0.70	-	0.70	-	0.35	-	0.35	-
Chemical composition (% DM)								
OM	93.6±0.09	93.4±0.08	94.2±0.61	94.0±0.30	95.6±0.70	95.7±0.54	96.4±0.27	96.3±0.33
Starch	32.3±0.91	28.4±1.93	32.8±1.40	29.3±1.37	50.1±2.85	48.2±0.87	51.6±2.27	48.5±0.76
CP	15.9±0.83	15.7±0.88	14.1±0.36	14.9±0.48	13.4±0.66	12.8±0.66	13.2±1.25	12.6±1.20
NDF	37.4±1.06	39.0±2.17	38.6±2.59	40.1±2.46	22.5±2.01	21.2±2.33	22.6±1.99	23.8±1.85
ADF	17.4±0.89	16.9±0.90	17.0±0.39	18.1±1.34	8.0±1.02	7.2±1.47	8.2±0.87	8.6±0.53
Ether extract	2.2±0.57	2.7±0.26	2.3±0.24	2.9±0.25	1.7±0.10	1.8±0.07	1.7±0.03	2.2±0.15
NEm (Mcal kg of diet DM^{-1})[d]	1.86	1.87	1.86	1.87	1.97	1.99	1.97	1.98
NEg (Mcal kg of diet DM^{-1})[d]	1.22	1.23	1.22	1.24	1.32	1.34	1.32	1.33

Note: OM, organic matter; CP, crude protein; NDF, neutral detergent fibre; ADF, acid detergent fibre.

[a]Corn-based dried distillers' grain plus solubles (DDGS) with low residual oil content (chemical composition % of DM Mean±SD, *n* = 4): 94.3±0.12 OM, 5.0±0.38 Starch, 34.5±1.19 CP, 29.2±1.19 NDF, 7.7±0.41 ADF, 5.6±0.43 Ether extract, 2.08 NE_m (Mcal kg of DM^{-1}), 1.42 NE_g (Mcal kg of DM^{-1}).

[b]Corn-based dried distillers' grain plus solubles (DDGS) with medium residual oil content (chemical composition % of DM Mean±SD, *n* = 4): 95.2±0.07 OM, 2.5±0.35 Starch, 32.4±1.05 CP, 36.9±1.47 NDF, 11.3±0.88 ADF, 8.3±0.22 Ether extract, 2.15 NE_m (Mcal kg of DM^{-1}), 1.47 NE_g (Mcal kg of DM^{-1}).

[c] Supplement contained (per kg) 572.02 g of ground barley, 250 g of calcium carbonate, 100 g of canola meal, 30 g of white salt, 25 g of molasses, 10 g of feedlot mineral, 10 g of canola oil, 2.32 g of Rumensin (Elanco Animal Health, Greenfield, IN; 25 mg of monensin kg^{-1} of DMI), and 0.66 g of vitamin E. It provided per kg DM: 15 mg copper, 58 mg zinc, 27 mg manganese, 0.66 mg iodine, 0.23 mg cobalt, 0.29 mg selenium, 4825 IU vitamin A, 478 IU vitamin D and 32 IU vitamin E.

[d]NEm, net energy for maintenance; NE_g, net energy for gain; were estimated according to NASEM (2016).

Table 2. Growth performance and diet NE_g of growing feedlot steers fed 10 or 20% (DM) of low- or medium-oil DDGS (LO-DDGS or MO-DDGS).

Item	LO-DDGS		MO-DDGS		SEM	*P*-value		
	10%	20%	10%	20%		DDGS	Level	DDGS × Level
Shrunk initial BW (kg)	294	294	296	296	3.4	0.42	0.98	0.99
Shrunk final BW (kg)	415	423	415	416	4.3	0.37	0.31	0.45
Shrunk total BW gain (kg)	122	128	118	121	2.5	0.05	0.08	0.47
DMI (kg d^{-1})	7.7	8.0	7.5	7.5	0.09	<0.01	0.13	0.26
ADG (kg)	1.43	1.52	1.39	1.42	0.029	0.03	0.06	0.35
Gain:Feed (kg kg^{-1})	0.1855	0.1905	0.1870	0.1877	0.00342	0.86	0.42	0.55
Diet NEg (Mcal kg^{-1})[a]	1.14	1.15	1.17	1.17	0.017	0.22	0.66	0.71

Note: BW, body weight; Shrunk BW = BW × 0.96; DMI, dry matter intake; ADG, average daily gain.
[a]NEg, net energy for gain, was calculated based on performance data as described by Ribeiro et al. (2016).

Table 3. Growth performance, diet NEg, carcass characteristics and liver abscesses of finishing feedlot steers fed 5 or 10% (DM) of low- or medium-oil DDGS (LO-DDGS or MO-DDGS).

	LO-DDGS		MO-DDGS			*P*-value		
Item	5%	10%	5%	10%	SEM	DDGS	Level	DDGS × Level
Shrunk initial BW (kg)	455	457	447	454	5.3	0.36	0.44	0.63
Shrunk final BW (kg)	665	668	666	670	4.8	0.71	0.50	0.91
Shrunk total BW gain (kg)	212	214	213	217	4.8	0.71	0.50	0.91
DMI (kg d^{-1})	11.5	11.7	11.0	11.4	0.23	0.11	0.24	0.67
ADG (kg)	1.87	1.90	1.88	1.92	0.043	0.71	0.50	0.91
Carcass adjusted ADG (kg)	1.86	1.89	1.90	1.93	0.048	0.43	0.53	0.99
Gain:Feed (kg kg^{-1})	0.1613	0.1608	0.1680	0.1685	0.00290	0.03	0.99	0.87
Carcass adjusted Gain:Feed (kg kg^{-1})	0.1613	0.1615	0.1720	0.1689	0.00351	0.02	0.70	0.64
Diet NEg (Mcal kg^{-1})[a]	1.28	1.28	1.33	1.34	0.029	0.09	0.97	0.89
Carcass characteristics[b]								
Carcass weight (kg)	414.4	420.4	416.1	419.2	4.52	0.96	0.32	0.75
Dressing percentage	60.2	60.4	60.7	60.3	0.25	0.35	0.70	0.25
Back fat (mm)	23.0	22.6	24.7	23.0	1.50	0.49	0.48	0.67
Rib eye area (cm)	88.4	88.5	87.6	89.5	1.18	0.94	0.39	0.44
Lean meat yield (%)[c]	48.7	48.7	47.1	48.5	1.21	0.48	0.56	0.56
Prime (%)[d]	2.6	2.5	10.5	5.0	-	0.20	0.64	0.66
AAA (%)[d]	92.3	95.0	89.5	95.0	-	0.73	0.32	0.73
AA (%)[d]	5.1	2.5	0.0	0.0	-	0.97	0.99	0.99
Abscessed livers (%)	43.6	55.0	47.4	40	-	0.39	0.99	0.32
Severely abscessed livers (%)[e]	10.3	12.5	5.3	10	-	0.40	0.42	0.67

Note: BW, body weight; Shrunk BW = BW × 0.96; DMI, dry matter intake; ADG, average daily gain; Carcass adjusted ADG = [(Carcass weight/0.60) – initial BW] / days on feed.

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[a]NEg, net energy for gain, was calculated based on performance data as described by Ribeiro et al. (2016).
[b]Steers were fed for a total of 232 d (84 d growing phase + 21 d transitioning + 112 d finishing phase + 15 d to shipping).
[c]Lean meat yield = 57.96 − 0.027 × (carcass weight) + 0.202 × (rib eye area) − 0.703 × (back fat thickness).
[d]Quality grades were determined according to Canadian Beef Grading Agency and expressed as percentage of total carcasses.
[e]Percentage of livers classified as A+ (1 or more active abscess > 2.5 cm diameter with inflammation of surrounding tissue).