

Evaluation of wheat-based dried distillers grains with solubles or canola meal derived from *Brassica napus* seed as an energy source for feedlot steers¹

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INTRODUCTION

Barley (*Hordeum vulgare* L.) has traditionally been the mainstay of the western Canadian feedlot industry with feedlot diets containing up to 90% barley grain (Beliveau and McKinnon, 2008; Damiran et al., 2014). Due to the expansion of bioethanol industry in North America, a large supply of bioethanol coproducts like wheat-based dried distillers' grains with solubles (wDDGS) is available. Barley grain and wDDGS average 12% and 39% CP, respectively, while energy values are similar. Therefore, wDDGS is becoming an increasingly common ingredient for beef cattle diets in western Canada and in the Northern Great Plains (Beliveau and McKinnon, 2008; Damiran et al., 2014). In parallel, Canada's 14 canola crushing and refining plants have the capacity to crush about 10.0

million tonnes of canola seed, and produce about 4 million tonnes of canola oil and 6 million tonnes of canola meal annually (Damiran et al., 2016). Thus, CM (42.6% CP; 71.5% TDN; Damiran et al., 2016) is expected to become a readily available and cost-effective feed ingredient for beef producers in North America. Traditionally, CM has been used as a protein source for ruminants (Kleinschmit et al., 2006), however with increasing supply and competitive pricing it is possible that the livestock sector will place increasing emphasis on its value as an energy source in addition to its protein value (Nair et al., 2015; Damiran et al., 2016). This shift would mimic what was observed over the last decade with corn and wDDGS (Walter et al., 2010; Nair et al., 2015). In order to establish these coproducts as a protein/energy source, they must be compared against other commonly used (conventional) feed sources such as barley. Further work is required to evaluate the energy value of these coproducts under pen fed conditions to further refine inclusion levels with respect to optimizing feedlot performance and carcass characteristics. The objectives of this study were to evaluate the effect of substitution of barley with wDDGS and CM at two levels in backgrounding and finishing diets with respect to performance and carcass characteristics of feedlot steers.

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MATERIALS AND METHODS

Animal Management and Experimental Design

Two hundred and sixty crossbred yearling steers (303.2 ± 23.0 kg; mean \pm SD) were purchased from commercial sources and shipped to the University of Saskatchewan Beef Cattle Research Unit (Saskatoon, Saskatchewan, Canada) for this trial. The animals were cared for according to guidelines of the [Canadian Council on Animal Care \(2009\)](#). Upon the arrival, initial processing included ear tagging for identification, treatment for parasites (Ivomec, Merial Canada, Baie D'Urfe', Quebec, Canada), implanting with Synovex S (Pfizer Canada, Inc., Kirkland, Quebec, Canada), as well as vaccinating for *Clostridial* diseases and *Haemophilus sommus* (UltraBac 7/ Somnubac, Pfizer Canada, Inc.), infectious bovine rhinotracheitis, parainfluenza 3, bovine respiratory syncytial virus, bovine viral diarrhoea (Bovi-Shield Gold 5, Pfizer Canada, Inc.), *Pasteurella haemolytica* (One Shot Pfizer Canada, Inc.), and treatment with a long-acting antimicrobial (Liquamycin LA, Pfizer Canada, Inc.). The steers were then randomly assigned within weight strata to one of eight pens (32 or 33 steers/pen) and each pen was randomly assigned to one of two dietary treatments ($N = 4$) in a completely randomized design. Following the backgrounding phase, all steers were re-implanted with Synovex S (Pfizer Canada, Inc.), 250 steers (405.4 ± 27.1 kg) and were stratified from lightest to heaviest BW (unshrunk BW), and re-assigned randomly within strata to 1 of 25 pens (10 steers/pen). Each pen was assigned randomly to one of the five dietary treatments ($N = 5$) for the 167-d finishing trial. The trial was designed as a completely randomized design with a two (type of coproduct: CM and wDDGS) by two (level of inclusion: 11 and 22%) factorial arrangement of treatments (CM11%, CM22%, wDDGS11%, and wDDGS22%), plus a control.

Diet Composition

During the backgrounding phase there were two diets: 1) the canola meal diet (**CM diet**: 14.2% CP; 69.0% TDN) consisted of 19.8% barley silage, 26.0% oat hulls, 6.4% barley straw, 25.8% barley grain, 15.3% canola meal, and 6.8% vitamin–mineral supplement (DM basis) and was formulated to target 1.6 kg/d gain; 2) the wDDGS diet (**wDDGS diet**) which was identical to the CM diet except wDDGS replaced CM. For the backgrounding

diets, the CM diet was somewhat greater in CP (14.2% vs. 13.7%) and ADF (26.2% vs. 23.5%, data not shown) than the wDDGS diet. The two backgrounding diets were identical in ash, Ca, and P.

During the finishing phase, the control diet was comprised of 88.7% barley grain, 5.8% barley silage, and 5.5% vitamin–mineral supplement (DM basis) and was formulated to 12.1% CP and 81.5% TDN. The four treatment diets were formulated to replace barley grain with CM or wDDGS at 11% and 22% of the diet. As expected, replacing barley with CM or wDDGS at 11% and 22% of the ration (DM basis), increased CP content of the diets from 12.1% in the control diet to 14.3% and 18.3% in the 11% and 22% CM diets and 15.0% and 17.5% for the 11% and 22% wDDGS diets, respectively. The ADF (11.6% vs. 13.6%) and P (0.5% vs. 0.6%) increased with increasing level of CM in the diet. In contrast, the ADF content of the diet was not affected by the inclusion of wDDGS (similar 10.0% in wDDGS included diets). In both feeding phases, all diets were formulated to meet or exceed [NRC \(2000\)](#) nutrient requirements for the targeted level of growth. Calcium to phosphorus ratios were formulated to range from 1.2:1 to 1.5:1. Monensin sodium (Rumensin 200; Elanco Animal Health, Guelph, Ontario, Canada) was incorporated in the vitamin–mineral supplement pellet and formulated to provide 33 mg/kg (DM basis).

Feeding and Feed Measurement

Prior to the start of the backgrounding trial, all steers were fed a common backgrounding diet [22% brome grass/alfalfa hay, 35% barley silage, 39% rolled barley, and 4% supplement (DM basis)]. Steers were transitioned to the final backgrounding diet in a two-step adaptation process in which the steers were fed 50% of the allocated CM or wDDGS diet for the first 3 d followed by the final diet for the remaining backgrounding phase. After the backgrounding trial, steers were adapted to the finishing diet in five steps by increasing the portion of feed barley (for control diet) or barley-wDDGS and CM mixture (for the treatment diets) in the TMR at the cost of forage (oat hulls, straw, and barley silage).

For both phases (backgrounding and finishing), feed was delivered ad libitum (target at least 5% orts), once daily at 0800 h using a Farm Aid Mixer Wagon equipped with a digital scale (model 430, Corsica, SD). The actual amount fed was based on the previous day's delivery and a visual assessment of the bunk prior to feeding. The

amount of feed provided to each pen was recorded daily. The barley grain was dry rolled (Ross Kamp Champion, Waterloo, IA) to a processing index of 76% and barley straw was ground in a tub grinder (Haybuster H-1000, DuraTech Industries International, Jamestown, ND) through a 9.5 cm screen.

Bunk samples of TMR were taken from each pen after delivery every 2 wk and were compiled by treatment. As well, every 2 wk, in the morning before feed delivery, the feed bunks were cleaned and the weight of orts was recorded and further sampled for DM analysis and discarded (in total ~0.6% of offered feed; DM basis). The DMI was calculated for each pen based on the amount (DM basis) of allotted feed and adjusted for orts.

Analysis of composite diet samples and ingredients was conducted by Cumberland Valley Analytical Services (Hagerstown, MD). Dietary NE_m content was calculated based on animal performance using the retained energy formula for large frame steer calves [$RE = 0.0493 \times BW^{0.75} \times ADG^{1.097}$; NRC 2000] as per Zinn et al. (2002). Net energy of gain was calculated from NE_m assuming $NE_g = NE_m \times 0.877 - 0.41$ as per Zinn and Shen (1998).

Animal Measurement

All steers were weighed for two consecutive days at the start and end of the each phase and every 2 wk throughout the trial for monitoring. Steer BW was reported as shrunk BW by multiplying BW by a correction factor of 0.96 to account for gut fill (NRC, 2000). The cattle G:F by pen was calculated as ADG/DMI . Ultrasound subcutaneous fat (USFAT, mm) and *longissimus thoracis* area (USLT, cm × cm) were determined at the start and end of the each feeding phase in conjunction with a weight day using an Aloka 500V real-time ultrasound machine (3.5 MHz; Aloka Inc., Wallingford, CT) equipped with a 17-cm linear array transducer.

Carcass Traits Measurement

The steers were slaughtered at Lakeside Packers (Brooks, Alberta, Canada). The cattle were sent to slaughter in five loads over a 2-mo period. Cattle were slaughtered once the pen average reached the target live weight of 645 kg (unshrunk basis). The steers were shipped the day prior to the kill date and held overnight in lairage. Carcass data such as HCW and grade scores were collected from the slaughter plant. The HCW was determined after

the hide was removed and the carcass eviscerated. The DP was calculated as the HCW divided by ship BW. Carcasses were chilled for 24 h, then traits were evaluated according to the Canadian Beef Grading Agency (2009) by a certified grader. Grade data included YG estimation and QG subjective estimates. The YG was estimated using the following equation: lean yield, % = $63.65 + 1.05$ (muscle score) $- 0.76$ (grade fat) and was based on length, width, and fat cover of the *longissimus dorsi* muscle between the 12th and 13th ribs. The QG scores were: B = devoid; A = trace marbling, AA = slight marbling; and AAA = small to moderate marbling; prime = slightly abundant or higher marbling (Canadian Beef Grading Agency, 2009).

Statistical Analysis

Pen was considered the experimental unit for all measures of steer performance as well as carcass characteristics during the finishing trial. For the backgrounding phase, steer performance data (BW, rib and rump fat, DMI, ADG, G:F, NE_m , and NE_g), were analyzed as a completely randomized design using the Proc Mixed Model procedure of SAS (2003); using the Kenward–Roger method. The model used for the analysis was: $Y_{ij} = \mu + T_i + e_{ij}$, where Y_{ij} was an observation of the dependent variable ij ; μ was the population mean for the variable; T_i was the fixed effect of diet (coproduct: wDDGS and CM); and e_{ij} was the random error associated with the observation ij . Means were determined using the least squares means statement of SAS and were separated using Tukey's multitreatment comparison method.

For the finishing trial, steer performance and carcass characteristics were analyzed as a completely randomized design with treatment as the fixed effect using the mixed model procedure of SAS (version 9.3; SAS Institute, Inc. Cary, NC). The experiment was designed as a 2×2 factorial arrangement, plus a control. First, all diets (diet) were compared against each other in a completely randomized design with Tukey's test used for mean separation. Second, coproduct type (type), level and type × level interaction were analyzed as a 2×2 factorial using data from just the CM and wDDGS treatments. Denominator degrees of freedom were determined using the Kenward–Roger option using the Satterthwaite adjustment. The QG scores were analyzed using the GLIMMIX macro (SAS, version 9.2; SAS Institute, Inc.) with a binomial error structure and logit data transformation. For all statistical analysis, pen was considered the experimental

Table 1. Effects of feeding wDDGS or canola meal on 64-d backgrounding performance of steers

Item	Diet type ^a		SEM	P value
	CM	wDDGS		
n, animals (pen)	32 (4)	33 (4)		
Shrunken BW, ^b kg				
Initial	291.0	290.5	0.20	0.13
Final	392.3	392.3	1.07	0.74
ADG, kg/d	1.61	1.62	0.02	0.62
DMI, kg/d	9.5	10.7	0.41	0.41
G:F, ^c kg/kg	0.18	0.15	0.014	0.30
NE _m , ^d Mcal/kg	1.68	1.50	0.109	0.29
NE _g , ^e Mcal/kg	1.06	0.91	0.095	0.29
USFAT, ^f mm				
Initial	2.1	2.2	0.13	0.71
Final	3.9	4.6	0.50	0.33
Gain, mm/d	0.03	0.04	0.008	0.38
USLT, ^g cm × cm				
Initial	47.6	47.8	0.39	0.75
Final	59.1	59.6	0.53	0.54
Gain, cm × cm/d	0.18	0.19	0.006	0.57

^aCM = steers supplemented with canola meal derived from *Brassica napus*; wDDGS = steers supplemented with wDDGS. The experimental unit was pen ($n = 4$).

^bShrunken BW calculated as 96% of live weight (NRC, 2000).

^cG:F is calculated as ADG/DMI.

^dCalculated based on performance (Zinn and Shen, 1998; Zinn et al., 2002).

^eUltrasound measurements of subcutaneous fat thickness.

^fUltrasound measurements of *longissimus dorsi* area.

unit, differences were considered significant at $P < 0.05$ and tendencies were discussed at $P < 0.10$. Coproduct type, level and type × level interaction were not significant ($P > 0.05$), therefore, P values were not reported.

RESULTS AND DISCUSSION

Backgrounding Performance

The effects of replacing barley with 15% CM or wDDGS on steer backgrounding performance are presented in Table 1. Initial BW (291 ± 22 kg, mean \pm SD), USFAT (2.15 ± 0.24 mm), as well as USLT (47.8 ± 0.73 cm²) were not different ($P > 0.05$) between steers in CM and wDDGS diets. Likewise, final BW (392 ± 29 kg), ADG (1.6 ± 0.2 kg/d), G:F (0.16 ± 0.03 kg/d), USFAT thickness (4.2 ± 1.01 mm), as well as USLT area (59.3 ± 1.01 cm²) did not differ between CM and wDDGS steer groups. Similar performance across the two backgrounding treatments can be explained based on the similar nutrient density of the diets and DMI. Ultimately, there was no treatment effect

($P < 0.05$) on dietary NE_m (1.6 ± 0.22 Mcal/kg) or NE_g (0.98 ± 0.19 Mcal/kg) content as calculated from animal performance. Overall, the results of this study suggested that either wDDGS or CM can be a viable source of energy and protein for growing beef steers and when fed at 15% of TMR in backgrounding diets will result in similar performance.

Finishing Performance

The effects of replacing barley with 11% and 22% CM or wDDGS on finishing performance are presented in Table 2. No type, level, and type × level interactions were detected ($P > 0.05$) on animal performance. The initial BW (391.3 ± 25.0 kg) and final BW (609.5 ± 29.4 kg) were similar ($P < 0.05$) among steer groups. Likewise, ADG (1.7 ± 0.1 kg/d) and DMI (11.3 ± 0.55 kg/d) were similar among the diets fed to the finishing steers, results which are in agreement with other studies (Damiran et al., 2014; Nair et al., 2015), where the substitution of barley grain with wDDGS and CM was evaluated on performance of feedlot cattle. The calculated NE for both maintenance and gain tended to decrease ($P = 0.09$; data not shown) with increasing dietary coproduct (both CM and wDDGS) from 11% to 22%. Thus, results of the current study indicate that the CM- and wDDGS-based diets had slightly lower energy content than the barley-based control diet. There were no differences ($P > 0.05$) among the treatments for USFAT and USLT gain and averaged 0.046 (SD = 0.009) mm/d and 0.238 (SD = 0.029) cm²/d, respectively. These results indicate that in finishing diets, inclusion of either coproduct at inclusion levels up to 22% did not have a significant impact on dietary energy content or performance of cattle relative to those fed a barley-based control diet.

Coproduct type, level and type × level interactions were not significant ($P > 0.05$) for any measured carcass traits (Table 3). The HCW (366.6 ± 20.3 kg), DP (59.9 ± 2.0 kg), and YG ($58.4 \pm 3.8\%$) were similar ($P > 0.05$) among treatments. In terms of quality grade approximately 51% of each treatment group graded Canada AAA/Prime.

CONCLUSIONS AND IMPLICATIONS

Results of the current study indicate that replacing of barley grain with CM or wDDGS at levels up to 15% of DM in backgrounding diets did not significantly affect animal performance. Likewise,

Table 2. Effects of feeding canola meal or wDDGS on the performance of finishing performance of steers

Item	Coproduct type (T) and inclusion level (L) in diet ^a					SEM	P value ^b
	Control	CM		wDDGS			
		10%	20%	10%	20%		
<i>n</i> , animals (pen)	10 (5)	10 (5)	10 (5)	10 (5)	10 (5)		
Shrunk BW, ^c kg							
Initial	390.0	391.0	390.6	392.0	391.4	11.62	1.00
Final	613.4	601.8	612.2	611.2	610.4	6.43	0.74
Days on feeding	137	121	129	125	128	11.5	0.92
ADG, kg/d	1.6	1.8	1.7	1.8	1.7	0.05	0.39
DMI, kg/d	10.9	11.3	11.7	11.3	11.4	0.24	0.28
G:F, kg/kg	0.15	0.16	0.15	0.16	0.15	0.004	0.06
USFAT, ^d mm							
Initial	4.3	4.4	3.9	3.9	4.5	0.35	0.56
Final	9.4	10.0	10.0	9.7	11.1	0.57	0.36
USLT, ^e cm × cm							
Initial	59.1	60.6	58.7	59.3	58.8	1.10	0.72
Final	88.1	89.4	88.8	88.9	91.5	1.59	0.62
NE _m , ^f Mcal/kg	1.87	1.86	1.81	1.89	1.85	0.025	0.30
NE _g , ^f Mcal/kg	1.23	1.22	1.18	1.25	1.21	0.022	0.30

^aCM = steers supplemented with canola meal derived from *Brassica napus*; wDDGS = steers supplemented with wDDGS; T = type of supplementation; L = level of inclusion; T × L = type × level interaction.

^bP value of diet based on all treatments including the control. The experimental unit was pen (*n* = 5). T, L, and T × L interaction was not observed (*P* > 0.05).

^cShrunk BW calculated as 96% of live weight (NRC, 2000).

^dUltrasound measurements of subcutaneous fat thickness.

^eUltrasound measurements of *longissimus dorsi* area.

^fCalculation based on performance (Zinn and Shen, 1998; Zinn et al., 2002).

Table 3. Effect of inclusion of canola meal derived from *Brassica napus* or wDDGS in the diet on carcass characteristics of feedlot steers

Item	Coproduct type (T) and inclusion level (L) in diet ^a					SEM	P value ^b
	Control	CM		wDDGS			
		11%	22%	11%	22%		
HCW, kg	367.5	363.6	368.8	367.5	366.5	4.69	0.95
DP, %	59.1	59.5	59.2	59.5	59.0	0.38	0.82
Lean yield, ^c %	58.6	58.8	58.9	58.8	57.2	0.74	0.43
Quality grade, ^d %							
Prime	2.0	—	4.0	—	—	1.41	0.21
Canada AAA	46.0	44.0	44.0	52.0	66.0	10.56	0.55
Canada AA	51.3	54.0	44.0	42.0	30.0	9.01	0.41
Canada A	—	—	2.0	2.0	—	1.26	0.57
Canada B4	—	2.0	2.0	2.0	2.0	1.55	0.74

^aCM = steers supplemented with canola meal; wDDGS = steers supplemented with wDDGS; T = type of supplementation; L = level of inclusion.

^bP value of diet based on all treatments including the control. The experimental unit was pen (*n* = 5). T, L, and T × L interaction was not observed (*P* > 0.05).

^cEstimated lean yield = 63.65 + 1.05 (muscle score) – 0.76 (grade fat) (Canadian Beef Grading Agency, 2009).

^dQuality grade: Canada Prime = marbling score 800; Canada AAA = marbling score 500; Canada AA = marbling score 400; Canada A = marbling score 300; B4, No yield grade (dark) (Canadian Beef Grading Agency, 2009).

replacing of barley grain with CM or wDDGS at levels up to 22% in barley-based finishing diets did not influence (positively or negatively) feedlot performance or carcass characteristics. Thus, replacing

barley with wDDGS or CM up to 22% of diet DM increased dietary protein content and other nutrients without drastic altering the energy value of barley-based diets. These results indicate that CM

or wDDGS can be used as a partial replacement for barley grain by the feedlot industry as an alternative energy source when the cost of barley grain is high.

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