Report to U.S. Grains Council - February 2016

Effect of corn dried distillers' grains plus solubles (DDGS) with medium and low residual oil content on growth performance of growing and finishing steers fed diets containing corn silage

G. O. Ribeiro Jr.*, M. Hünerberg*†, D. J. Gibb† and T. A. McAllister*

*Agriculture and Agri-Food Canada, Lethbridge Research Centre, Lethbridge, Alberta, Canada T1J 4B1; †Gowans Feed Consulting, Wainwright, Alberta, Canada T9W 1L2.

Abstract

The objective of this study was to compare the effect of dried distillers' grains plus solubles (**DDGS**) with low and medium oil content (**LoDDGS**: 5.6%; **MoDDGS**: 8.3%, dry matter [**DM**]) on feed intake, feed efficiency and carcass quality of growing and finishing cattle. The study used 160 steers (307 ± 21.1kg) in a complete randomized design with a 2×2 factorial treatment structure and consistent of a growing (84d) and finishing stage (112d). Steers were randomly assigned to 16 standard pens (10 steers/pen) and offered one of four diets (four pens/diet). Growing diets contained (DM basis): 1) 60% corn silage, 24.3% barley, 10% LoDDGS, 5% supplement, 0.7% urea; 2) 60% corn silage, 15% barley, 20% Lo- DDGS, 5% supplement; 3) 60% corn silage, 24.3% barley, 10% MoDDGS, 5% supplement, 0.7% urea; 4) 60% corn silage, 15% barley, 20% MoDDGS, 5% supplement. After completion of the growing stage steers were transitioned to finishing diets. Treatment allocation was maintained. Finishing diets contained (DM basis): 1) 10% corn silage, 79.65% barley, 5% LoDDGS, 5% supplement, 0.35% urea; 2) 10% corn silage, 75% barley, 10% LoDDGS, 5% supplement; 3) 10% corn silage, 79.65% barley, 5% MoDDGS, 5% supplement, 0.35% urea; 4) 10% corn silage, 75% barley, 10% MoDDGS, 5% supplement. Feeding LoDDGS during the growing period resulted in higher DM intake (P=0.002) and increased average daily gain (**ADG**; P=0.03) compared to MoDDGS, while steers supplemented with 20% DDGS tended to produce higher ADG compared to 10% DDGS inclusion (P=0.06). In contrast, steers fed MoDDGS during finishing displayed improved feed conversion efficiency compared to those fed LoDDGS (P=0.03). Carcass quality and liver scores were not affected by inclusion level or DDGS type. Overall, LoDDGS might have maximum feeding value in growing diets due to its higher protein content whereas DDGS with higher residual oil content has higher feeding value in finishing diets.

Background

Due to the low crude protein (**CP**) content of corn silage (8.0-9.5%; dry matter [**DM**] basis; NRC. 2000) supplemental CP is needed to maintain optimum growth rate in cattle fed corn silage-based diets (McKinnon et al., 1993). The large expansion of the North American grain ethanol industry over the last 20 years resulted in a high availability of ethanol co-products, such as wet, modified and dried distillers' grains plus solubles (**DDGS**). To date DDGS has become one of the most frequently used protein supplements in the North American beef feeding industry (Renewable Fuels Association, 2015). As starch is almost completely removed from the grain and converted into ethanol and CO_2, the remaining nutrients in DDGS (fibre, CP, fat and minerals) are concentrated about three fold compared to the unprocessed grain (Spiehs et al., 2002).

Since corn DDGS has a relatively high oil content (10-14% DM basis; NRC, 2000; Spiehs et al., 2002; Klopfenstein et al., 2008) and corn oil can be marketed for other applications such as production of biodiesel, ethanol producers started to implement enhanced oil extraction technologies to improve the recovery of corn distillers' oil (**CDO**; U.S. Grains Council, 2012). By 2014 approximately 85% of dry mills in the U.S. implemented CDO extraction techniques and produced approximately 1.1 billion kg of CDO/year (Renewable Fuels Association, 2015). Corn distillers' oil is typically removed by mechanical (i.e., centrifugation) or solvent extraction while the method of CDO removal has impact on the chemical composition, in particular the residual fat content, of DDGS. Solvent-extraction of CDO typically produces DDGS with a low fat content between 3.5 to 5.0% (DM basis), while ethanol plants that use mechanical separation and centrifuge CDO off the distillers' solubles and add the de-oiled solubles back to the distillers' produce DDGS with a higher residual fat content of 6.0 to 9.0% (DM basis). Feeding non-extracted DDGS to ruminants has in general positive impact on their growth performance, a finding which can partly be attributed to its high oil content (Klopfenstein et al., 2008). O'Hara et al. (2011) reported that the average daily gain (**ADG**) of lambs fed high-oil DDGS (**Ho-DDGS**) was improved by 17% (345 g/d) compared to lambs fed low-oil DDGS (285 g/d), although ruminal fermentation parameters were not affected by the oil content of DDGS. Lodge et al. (1997) supplemented fat or protein to wet corn gluten feed to mimic distillers' grains and observed that feed efficiency was reduced when either fat or protein were removed, which suggest that the fat content contributes to the nutritional value of distillers' grains. Supplementation with DDGS is also believed to have positive impact on forage digestion in the rumen. For example, Benton et al. (2007) evaluated growth performance of cattle fed diets containing wet distillers' grains plus solubles (**WDGS**) at 30% of diet DM with three types of roughage (alfalfa hay, corn silage and corn stalks) containing average or high levels of neutral detergent fiber (**NDF**). Results from this study suggest that WDGS exhibited positive associative effects when fed in combination with low-quality forages like corn stalks.

Although numerous studies examined the feeding value of conventional DDGS in cattle diets there is a lack of published research investigating the effect of low and medium-oil DDGS (**LoDDGS**, **MoDDGS**) as a protein source for beef cattle fed diets containing corn silage.

Objectives

The objective of this study was to examine the impact of MoDDGS and LoDDGS on feed intake, feed efficiency and carcass quality of growing and finishing beef cattle offered diets containing corn silage.

Materials and methods

The study was conducted at the beef cattle research feedlot located at Agriculture and Agri-Food Canada's Lethbridge Research Centre. Cattle were cared for in accordance with guidelines published by the Canadian Council on Animal Care (CCAC, 2009).

Experimental design, animals, and diets

A combined growing (84d) and finishing (112d) study was conducted using 160 Angus and Angus crossbreed steers (307 ± 21.1 kg initial live body weight [**BW**]). The study used a completely randomized design with a 2 × 2 factorial treatment structure (LoDDGS, MoDDGS × two dietary inclusion levels). Upon arrival at the feedlot, 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). On d1 of the experiment steers were implanted with Component TE-100 (100mg trenbolone acetate, 10mg estradiol and 29mg tylosin tartrate; Elanco Animal Health, Guelph, Ontario, Canada). Ninety days prior to the end of the experiment steers were reimplanted with Component TE-S (120mg trenbolone acetate, 24mg estradiol and 29mg tylosin tartrate; Elanco Animal Health, Guelph, Ontario, Canada).

Steers were weighed before feeding on d0 and d1 to determine their initial BW. Weights obtained on d 0 were used to block steers into groups with similar average BW. Steers were assigned to 16 pens (10 steers/pen) and pens were randomly assigned to one of four diets (four pens/diet). Each pen measured 17 × 12.7 m. Pens were separated by wind fences on two sides and steers had free access to fresh water. Growing diets contained (DM basis): 1) 60% corn silage, 24.3% barley grain, 10% LoDDGS, 5% mineral vitamin supplement, 0.7% urea; 2) 60% corn silage, 15% barley grain, 20% LoDDGS, 5% mineral vitamin supplement; 3) 60% corn silage, 24.3% barley grain, 10% MoDDGS, 5% mineral vitamin supplement, 0.7% urea; 4) 60% corn silage, 15% barley grain, 20% MoDDGS, 5% mineral vitamin supplement (Table 1). After completion of the growing stage (84d) steers were transitioned to high-grain finishing diets over 21d. Treatment allocation was maintained in the fishing stage (112d) while the concentration of LoDDGS and MoDDGS was reduced to 5% and 10% DM to adjust for the higher CP content of basal diets and lower protein requirements of finishing cattle. Finishing diets contained (DM basis): 1) 10% corn silage, 79.65% barley grain, 5% LoDDGS, 5% mineral vitamin supplement, 0.35% urea; 2) 10% corn silage, 75% barley grain, 10% LoDDGS, 5% mineral vitamin supplement; 3) 10% corn silage, 79.65% barley grain, 5% MoDDGS, 5% mineral vitamin supplement, 0.35% urea; 4) 10% corn silage, 75% barley grain, 10% MoDDGS, 5% mineral vitamin supplement (Table 2). To minimize variation in chemical composition MoDDGS (Blue Flint Ethanol; Washburn, North Dakota, U.S.) and LoDDGS (POET Biorefining, Groton, South Dakota, U.S.) were sourced as single lots sufficient for the complete experiment. The supplement provided calcium, salt, trace minerals and vitamins. The supplement also contained rumensin premix (Rumensin 200 Premix; Elanco Animal Health, Guelph, Ontario, Canada) to provide 25 mg monesin sodium/kg of the complete diet (DM basis). Urea (0.7% and 0.35% DM) was added to low-DDGS diets to achieve similar concentration of CP compared to those with higher DDGS inclusion level. Barley grain was dry rolled to a target processing index (vol. weight after processing/ vol. weight before processing × 100) of 80% ± 3%. Diets were prepared as total mixed rations (TMR). Steers were fed once daily at approximately 1000 h for ad libitum intake. Feed delivery was recorded daily and orts were collected weekly to determine DM intake (**DMI**).

Growth performance and energy content of the diet

To obtain individual mean BW steers were weighed before feeding time on two consecutive days at the beginning of the experiment, end of growing, beginning of finishing, and the end of the experiment. Interim BW (single weigh days) were taken every 21d during the growing and every 28d during finishing stage. To account for gut fill shrunk BW (BW × 96%) was used to calculate growth performance parameters such as average daily gain (**ADG**; [final BW - initial BW]/number of days on feed) and feed conversion efficiency (**G:F**; ADG/DMI).

Net energy gain (**NE$_g$**) of the diets was calculated according to Zinn et al. (2002) and Gibb et al. (2008). The NE$_g$ for each diet was determined using the formula for retained energy for large-framed yearling steers (NRC, 1984): $EG = 0.0493 \times [MW \times (478/650)]^{0.75} \times (ADG)^{1.097}$, where EG is energy gained (Mcal/d), and MW is average shrunk BW (kg) for the respective feeding period [(initial BW × 0.96 + final BW × 0.96)/2].

Diet Sampling and Chemical Analyses

Diets, orts, and diet ingredients were sampled weekly oven dried at 55°C to determine DM content. For chemical analysis sub samples were composited by weighing period (21d growing part, 28d finishing part) and ground through a 1 mm screen (Cutting Mill SM100; Retsch, Haan, Germany). Analytical DM was determined by drying at 135°C for 2 h (AOAC, 2005; method 930.15), followed by hot weighing. Organic matter (**OM**) was calculated as the difference between 100 and the percentage of ash (AOAC, 2005; method 942.05). Neutral detergent fibre (**NDF**) and acid detergent fibre (**ADF**), both expressed inclusive of residual ash were quantified as described by Van Soest et al. (1991) using amylase and sodium sulfite for the NDF analysis. Fat was determined according to AOAC (2006; method 2003.06) using petroleum ether extraction (Extraction Unit E-816 HE; Büchi Labortechnik AG, Flawil, Switzerland). For the measurement of CP (N × 6.25) and starch, samples were reground using a ball mill (Mixer Mill MM2000, Retsch, Haan, Germany). 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 as described by Rode et al. (1999).

Carcass measurement

Carcass characteristics including warm carcass weight (with internal fat removed), dressing percentage, back fat thickness, and quality grade were obtained at harvest. Liver scoring followed the Elanco system where scores are as follows: 0 (no abscesses), A- (1 or 2 small abscesses or abscess scars), A (2 to 4 well organized abscesses less than 2.5 cm diameter), or A+ (1 or more large active abscesses > 2.5 cm diameter with inflammation of surrounding tissue).

Statistical analysis

Data were analyzed as completely randomized design with a 2 × 2 factorial treatment structure (LoDDGS, MoDDGS × 10% and 20% inclusion in the growing and 5% and 10% inclusion in the finishing phase; DM basis) using the MIXED model procedure of SAS (SAS Inst. Inc., Cary, NC). Pen was used as experimental unit and initial BW was used as a covariate for DMI and growth performance parameters (weight gain, ADG and gain-to-feed ratio). Individual steer was the experimental unit for carcass measurements and liver scores. The GLIMMIX procedure was used to analyze proportion of cattle with abscessed and severely abscessed livers (A and A+) and quality grade (AA, AAA or Prime). Treatment difference was analyzed using the LSMEANS statement with the PDIFF option. Significance was declared at $P \leq 0.05$. Trends were discussed at $P < 0.10$.

Results

Residual oil content of LoDDGS was 5.61 ± 0.43% while the oil content of MoDDGS was nearly 50% higher (8.30 ± 0.22%; mean ± SD; DM basis). Feeding LoDDGS during the growing period resulted in higher DMI (P=0.002) and increased ADG (P=0.03) compared to MoDDGS (Table 3). Steers offered 20% DDGS tended to have higher ADG (P=0.06) compared to those fed 10% DDGS supplemented with urea (DM basis).

Feeding MoDDGS to finishing steers resulted in improved feed conversion efficiency compared to LoDDGS (P=0.03; Table 4). Other growth performance parameters were unaffected by dietary treatments. Similarly, carcass quality and occurrence of liver abscesses were not affected by type of DDGS, DDGS inclusion level or their interaction (Table 5).

Conclusion

Feeding LoDDGS during the growing period resulted in higher DMI and increased ADG compared to MoDDGS, whereas steers offered 20% DDGS tended to have higher ADG compared to those fed 10% DDGS plus 0.7% urea (DM basis). Feeding MoDDGS to finishing steers resulted in improved feed conversion efficiency compared to LoDDGS. These findings suggest that LoDDGS might exhibit higher feeding value in growing diets while DDGS with higher residual oil content has higher feeding value in beef finishing diets.

Acknowledgment

This study was conducted with funding from the North Dakota Corn Utilization Council, North Dakota Ethanol Utilization Council, U.S. Grains Council, and AAFC Canada. The authors thank Wendi Smart, Brant Baker, and Cody Barnson for their technical assistance. We also thank the barn staff of the Lethbridge Research Center for the care and management of the steers.

References

AOAC. 2005. Official Methods of Analysis, 18th ed. Assoc. Off. Anal. Chem., Gaithersburg, MD.

AOAC. 2006. Official Methods of Analysis, 18th ed., Revisions 1. Assoc. Off. Anal. Chem., Gaithersburg, MD.

Benton, J. R., G. E. Erickson, T. J. Klopfenstein, K. J. VanderPol, and M. A. Greenquist. 2007. Effects of roughage source and level in finishing diets containing wet distillers grains on feedlot performance. J. Anim. Sci. 85(Suppl. 2):76. (Abstr.)

Canadian Beef Grading Agency. 2009. Canadian beef grading standards. http://www.canadianbeef.info/ca/en/fs/quality/Standards/default.aspx

Canadian Council on Animal Care. 2009. CCAC guidelines on: the care and use of farm animals in research, teaching and testing. Ottawa ON Canada. http://www.ccac.ca/en_/standards/guidelines

Gibb, D. J., X. Hao, and T. A. McAllister. 2008. Effect of dried distillers grains from wheat on diet digestibility and performance of feedlot cattle. Can. J. Anim. Sci. 88:659–665.

Klopfenstein, T. J., G. E. Erickson, and V. R. Bremer. 2008. BOARD-INVITED REVIEW: Use of distillers by-products in the beef cattle feeding industry. J. Anim. Sci. 86:1223-1231.

Lodge, S. L., R. A. Stock, T. J. Klopfenstein, D. H. Shain, and D. W. Herold. 1997. Evaluation of wet distillers composite for finishing ruminants. J. Anim. Sci. 75:44–50.

McKinnon, J. J., R. D. H. Cohen, S. D. M. Jones, and D. A. Christensen. 1993. Crude protein requirements of large frame cattle fed two levels of energy as weaned calves or as backgrounded yearlings. Can. J. Anim. Sci. 73:315–325.

NRC. 2000. Nutrient requirements of beef cattle. 7th rev. ed.: Update 2000. Natl. Acad. Press, Washington, DC.

O'Hara, A. S., A. Tanner, T. A. McAllister, D. J. Gibb, F. van Herk and A. V. Chaves. 2011. Effect of low and high oil corn distillers' grain on rumen fermentation, growth performance and carcass characteristics of lambs. Anim. Prod. Sci. 51:708-716.

Renewable Fuels Association (RFA). 2015. Going Global-2015 Ethanol Industry Outlook. http://www.ethanolrfa.org/resources/publications/outlook/

Rode, L.M., W.Z. Yang, and K. A. Beauchemin. 1999. Fibrolytic enzyme supplements for dairy cows in early lactation. J. Dairy Sci. 82:2121–2126.

Spiehs, M. J., Whitney, M. H. and Shurson, G. C. 2002. Nutrient database for distillers dried grains with solubles produced from new ethanol plants in Minnesota and South Dakota. J. Anim. Sci. 80:2639–2645.

U.S. Grains Council. 2012. The U.S. Grains Council DDGS User Handbook (3rd Edition). http://www.grains.org/index.php/buying-selling/ddgs-user-handbook

Van Soest, P. J., J. B. Robertson, and B. A. Lewis. 1991. Symposium: Carbohydrate methodology, metabolism, and nutritional implications in dairy cattle. Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition. J. Dairy Sci. 74:3583–3597.

Zinn, R. A., F. N. Owens, and R. A. Ware. 2002. Flaking corn: Processing mechanics, quality standards, and impacts on energy availability and performance of feedlot cattle. J. Anim. Sci. 80:1145–1156.

Table 1. Ingredient composition of growing diets

Diet ingredient, % of DM	Diet			
	10% LoDDGS	20% LoDDGS	10% MoDDGS	20% MoDDGS
Corn silage	60.00	60.00	60.00	60.00
Barley grain, dry-rolled	24.30	15.00	24.30	15.00
Low-oil DDGS[1]	10.00	20.00	-	-
Medium-oil DDGS[2]	-	-	10.00	20.00
Mineral/vitamin supplement[3]	5.00	5.00	5.00	5.00
Urea	0.70	-	0.70	-

[1]Corn-based dried distillers' grain plus solubles (DDGS) with low residual oil content (5.6% DM).
[2]Corn-based dried distillers' grain plus solubles (DDGS) with medium residual oil content (8.3% DM).
[3]Supplied per kg DM: 65 mg Zn, 28 mg Mn, 15 mg Cu, 0.7 mg I, 0.2 mg Co, 0.3 mg oSe, 6,000 IU vitamin A, 600 IU vitamin D, and 47 IU vitamin E.

Table 2. Ingredient composition of finishing diets

Diet ingredient, % of DM	Diet			
	5% LoDDGS	10% LoDDGS	5% MoDDGS	10% MoDDGS
Corn silage	10.00	10.00	10.00	10.00
Barley grain, dry-rolled	79.65	75.00	79.65	75.00
Low-oil DDGS[1]	5.00	10.00	-	-
Medium-oil DDGS[2]	-	-	5.00	10.00
Mineral/vitamin supplement[3]	5.00	5.00	5.00	5.00
Urea	0.35	-	0.35	-

[1]Corn-based dried distillers' grain plus solubles (DDGS) with low residual oil content (5.6% DM).
[2]Corn-based dried distillers' grain plus solubles (DDGS) with medium residual oil content (8.3% DM).
[3]Supplied per kg DM: 65 mg Zn, 28 mg Mn, 15 mg Cu, 0.7 mg I, 0.2 mg Co, 0.3 mg oSe, 6,000 IU vitamin A, 600 IU vitamin D, and 47 IU vitamin E.

Table 3 Growth performance and diet NEg of growing steers fed 10 and 20% (DM) low and medium oil DDGS (LoDDGS, MoDDGS)

	LoDDGS		MoDDGS			*P*-value		
Item	10%[1]	20%[1]	10%[1]	20%[1]	SEM	DDGS	Level	DDGS × Level
Shrunk initial BW, kg	293.6	293.6	296.2	296.1	3.35	0.42	0.98	0.99
Shrunk final BW, kg	415.1	422.7	414.5	415.6	4.26	0.37	0.31	0.45
Shrunk total BW gain, kg	121.6	128.1	118.1	120.9	2.47	0.05	0.08	0.47
ADG, kg								
d 0 to 21	1.50	1.75	1.45	1.36	0.058	0.003	0.20	0.01
d 0 to 42	1.50	1.61	1.40	1.38	0.044	0.003	0.35	0.18
d 0 to 63	1.46	1.57	1.40	1.41	0.044	0.03	0.18	0.25
d 0 to 84	1.43	1.52	1.39	1.42	0.029	0.03	0.06	0.35
DMI, kg/d								
d 0 to 21	6.92	7.42	6.90	6.71	0.103	0.004	0.15	0.005
d 0 to 42	7.20	7.53	7.01	6.90	0.099	0.002	0.29	0.05
d 0 to 63	7.43	7.69	7.29	7.17	0.097	0.005	0.49	0.07
d 0 to 84	7.71	7.98	7.45	7.49	0.093	0.002	0.13	0.26
G:F								
d 0 to 21	0.216	0.231	0.211	0.192	0.0096	0.04	0.81	0.10
d 0 to 42	0.209	0.214	0.200	0.196	0.0071	0.09	0.96	0.55
d 0 to 63	0.196	0.199	0.193	0.194	0.0058	0.49	0.72	0.88
d 0 to 84	0.186	0.191	0.187	0.188	0.0034	0.86	0.42	0.55
Dietary energy content								
NE_g, Mcal/kg	1.14	1.15	1.17	1.17	0.017	0.22	0.66	0.71

[1]Composition (DM basis) growing diets: 10%LoDDGS=60% corn silage, 24.3% barley grain, 10% low-oil DDGS (5.6% fat), 5% mineral vitamin supplement, 0.7% urea; 20%LoDDGS=60% corn silage, 15% barley grain, 20% low-oil DDGS (5.6% fat), 5% mineral vitamin supplement; 10%MoDDGS=60% corn silage, 24.3% barley grain, 10% medium-oil DDGS (8.3% fat), 5% mineral vitamin supplement, 0.7% urea; 20%MoDDGS=60% corn silage, 15% barley grain, 20% medium-oil DDGS (8.3% fat), 5% mineral vitamin supplement.

Table 4 Growth performance and diet NEg of finishing steers fed 5 and 10% (DM) low and medium oil DDGS (LoDDGS, MoDDGS)

	LoDDGS		MoDDGS[1]			*P*-value		
Item	5%[1]	10%[1]	5%[1]	10%[1]	SEM	DDGS	Level	DDGS × Level
Shrunk initial BW, kg	454.9	456.5	447.3	454.1	5.26	0.36	0.44	0.63
Shrunk final BW, kg	665.1	667.9	666.4	670.2	4.83	0.71	0.50	0.91
Shrunk total BW gain, kg	211.7	214.4	212.9	216.8	4.83	0.71	0.50	0.91
ADG, kg								
d 0 to 28	1.88	2.07	2.01	2.15	0.112	0.38	0.16	0.79
d 0 to 56	2.11	2.11	2.19	2.18	0.079	0.38	0.93	0.93
d 0 to 84	1.97	1.95	2.01	2.01	0.058	0.40	0.88	0.96
d 0 to 112	1.87	1.90	1.88	1.92	0.043	0.71	0.50	0.91
DMI, kg/d								
d 0 to 28	10.36	10.93	9.72	10.59	0.202	0.03	0.004	0.47
d 0 to 56	10.99	11.40	10.42	10.98	0.221	0.05	0.05	0.74
d 0 to 84	11.32	11.55	10.84	11.22	0.233	0.10	0.21	0.74
d 0 to 112	11.51	11.69	11.03	11.40	0.227	0.11	0.24	0.67
G:F								
d 0 to 28	0.181	0.192	0.206	0.203	0.0081	0.05	0.62	0.38
d 0 to 56	0.192	0.185	0.207	0.199	0.0059	0.04	0.23	0.93
d 0 to 84	0.172	0.170	0.185	0.179	0.0036	0.01	0.27	0.66
d 0 to 112	0.161	0.161	0.168	0.169	0.0029	0.03	0.99	0.87
Dietary energy content								
NEg, Mcal/kg	1.28	1.28	1.33	1.34	0.029	0.09	0.97	0.89

[1]Composition (DM basis) finishing diets: 5%LoDDGS=10% corn silage, 79.65% barley grain, 5% low-oil DDGS (5.6% fat), 5% mineral vitamin supplement, 0.35% urea; 10%LoDDGS=10% corn silage, 75% barley grain, 10% low-oil DDGS (5.6% fat), 5% mineral vitamin supplement; 5%MoDDGS=10% corn silage, 79.65% barley grain, 5% medium-oil DDGS (8.3% fat), 5% mineral vitamin supplement, 0.35% urea; 10%MoDDGS=10% corn silage, 75% barley grain, 10% medium-oil DDGS (8.3% fat), 5% mineral vitamin supplement.

Table 5. Carcass characteristics and liver abscess incidence of feedlot steers fed two levels of dried distillers' grains plus solubles (DDGS) with medium or low residual oil content (MoDDGS, LoDDGS)

	LoDDGS[1]		MoDDGS[1]			*P*-value		
Item	5%	10%	5%	10%	SEM	DDGS	Level	DDGS × Level
Carcass weight, kg	414.4	420.4	416.1	419.2	4.52	0.96	0.32	0.75
Backfat, mm	23.0	22.6	24.7	23.0	1.50	0.49	0.48	0.67
Ribeye area, cm^2	88.4	88.5	87.6	89.5	1.18	0.94	0.39	0.44
Meat yield, %	48.7	48.7	47.1	48.5	1.21	0.48	0.56	0.56
Prime,[2] %	2.6	2.5	10.5	5.0	-	0.20	0.64	0.66
AAA,[2] %	92.3	95.0	89.5	95.0	-	0.73	0.32	0.73
AA,[2] %	5.1	2.5	0.0	0.0	-	0.97	0.99	0.99
Abscessed livers, %	43.6	55.0	47.4	40.0	-	0.39	0.99	0.32
Severely abscessed livers,[3] %	10.3	12.5	5.3	10.0	-	0.40	0.42	0.67

[1]Composition (DM basis) finishing diets: 5%LoDDGS=10% corn silage, 79.65% barley grain, 5% low-oil DDGS (5.6% fat), 5% mineral vitamin supplement, 0.35% urea; 10%LoDDGS=10% corn silage, 75% barley grain, 10% low-oil DDGS (5.6% fat), 5% mineral vitamin supplement; 5%MoDDGS=10% corn silage, 79.65% barley grain, 5% medium-oil DDGS (8.3% fat), 5% mineral vitamin supplement, 0.35% urea; 10%MoDDGS=10% corn silage, 75% barley grain, 10% medium-oil DDGS (8.3% fat), 5% mineral vitamin supplement.

[2]Expessed as percentage of total carcasses. Quality grades were based on Canadian Beef Grading Agency (2009).

[3]Percentage of livers classified as A (2 to 4 well organized abscesses <2.5 cm diameter) and A+ (1 or more active abscess > 2.5 cm diameter).