PE9.26 Comparison of wheat- versus corn-based dried distillers' grains with solubles on fatty acid composition of feedlot cattle 168.00

Noelia Aldai (1) noelia.aldai@agr.gc.ca, MER Dugan(1), JL Aalhus (1), TA McAllister (2) L-AJ Walter (3) JJ McKinnon (3)

(1)Lacombe Research Centre, Agriculture & Agri-Food Canada, Lacombe, AB, Canada

(2)Lethbridge Research Centre, Agriculture & Agri-Food Canada, Lethbridge, AB, Canada

(3)Department of Animal & Poultry Science, University of Saskatchewan, Saskatoon, SK, Canada

***Abstract*—Ethanol production has increased in Canada and USA creating new opportunities for feeding lower cost by-products to cattle. Given the limited information available on the effects of substituting barley for corn or wheat distillers' grains with solubles (DDGS) on beef fatty acid profile, the objective of this study was to compare a barley-based control diet to the effects of including wheat or corn DDGS at 20% and 40% dry matter with special emphasis on *trans*-18:1 profile. Twenty animals from each of the treatments were finished to a final target unshrunk live weight of 645kg. Backfat levels of total saturated, non-conjugated non-methylene interrupted dienes, and conjugated linoleic acids were unaffected by replacing barley with corn or wheat DDGS. Monounsaturates were higher in control samples while polyunsaturates were higher in backfat from DDGS fed cattle. Overall, backfat from control (barley-based) and wheat DDGS fed animals had lower levels of *trans*-18:1 and consequently had lower levels of individual *trans*-18:1 isomers and an improved (higher) 11*t*-/10*t*-ratio compared to backfat from corn DDGS fed animals.**

N. Aldai (corresponding author; phone: +1-403-7828569; fax: +1-403-7826120; e-mail: noelia.aldai@agr.gc.ca, noeliaaldai@hotmail.com).

***Index Terms*—beef, distillers' grains, fatty acids, *trans*.**

I. INTRODUCTION

PRODUCTION of biofuels in north America as a renewable energy source has been increasing to lower dependence on foreign fossil fuels and reduce greenhouse gas emissions. As a result, western Canada is experiencing a significant increase in wheat-based ethanol production which in turn provides by-products to livestock producers for feeding. Although wheat-based dried distillers' grains with solubles (DDGS) have the potential to provide an extensive feed base for western Canada's livestock industry, production of corn DDGS in the USA is widespread and may have the potential to be cost competitive in Canada.

Ethanol production removes starch from grain and increases crude protein, fat and fiber levels. On dry matter (DM) basis, fat levels increase from 3.5-4.7 to 9-12% in corn DDGS, and from 1.6-2 to 2.5-6.7% in wheat DDGS [1]. However, compared with whole grains, there has been little research conducted on the effect of DDGS on beef lipid content and fatty acid composition. Cattle in western Canada are typically finished on diets containing high levels of barley, and substitution of a certain percentage of barley with corn or wheat-based DDGS might create an opportunity to enhance beef fatty acid profile.

Rumen bacteria isomerize and hydrogenate polyunsaturated fatty acids (PUFA) and metabolic intermediates can accumulate amongst which rumenic acid (9*c*,11*t*-18:2) and its precursor vaccenic acid (11*t*-18:1) have known health benefits [2]. However, the profile of *trans*-18:1 produced has been demonstrated to depend mainly, on the diet. Rations based on ground barley produce higher levels of 10*t*-18:1 [3] which has been associated with coronary heart disease [4]. On the other hand, finishing cattle on forage has been shown to increase specifically the 11*t*-18:1 isomer relative to 10*t*-18:1 [5]. Feeding DDGS, in general, reduces dietary starch and increases crude fibre level which could result in a more neutral and stable rumen pH and, potentially, favour 11*t*-18:1 production [6]. Dugan et al. [7] reported an improved profile of biohydrogenation products when feeding wheat DDGS at several levels. Besides, it is known that high levels of PUFA in beef would increase its susceptibility to oxidation with possible effects on colour stability, rancidity and off-flavour development. However, when we compared a barley-based control diet to the effect of including wheat or corn DDGS at 20% and 40% of DM on meat quality and sensory parameters no significant negative effects were found (unpublished results). Herein, the fatty acid composition of finishing steers from the same study has been reported with special emphasis on *trans*-18:1 isomers.

II. MATERIALS AND METHODS

Animals, management and diet composition

This trial commenced in November of 2007 at the University of Saskatchewan - Beef Cattle Research

Station (SK, Canada). It involved 300 steers and 5 feed treatments (60 animals per treatment) where DDGS replaced barley grain on a DM basis. Diets included: control (86.6% rolled barley, 5.7% supplement, and 7.7% barley silage in DM basis, no DDGS), 20% corn DDGS, 20% wheat DDGS, 40% corn DDGS, and 40% wheat DDGS. Fatty acid methyl esters (FAME) from the finishing diets were prepared according to Sukhija and Palmquist [8].

From the 300 steers on test, 100 were selected for in-depth meat quality assessment. Four animals from each of the 5 feed treatments were selected on each slaughter date based on a target end-point of 645kg live weight (unshrunk basis). Animals for each slaughter were loaded as a group (n = 20) at the University of Saskatchewan - Beef Cattle Research Station and were transported (approx. 6h) to the Agriculture and Agri-Food Canada (AAFC) - Lacombe Research Centre (LRC, AB, Canada). Upon receipt at AAFC-LRC, animals were held in lairage overnight with free access to water. Animals were slaughtered the following day at the AAFC - LRC abattoir. All animals through each aspect of this study were cared for according to guidelines established by the Canadian Council on Animal Care [9].

Slaughter and Sample Collection

At the time of slaughter, animals were stunned, exsanguinated and dressed in a simulated commercial manner. Following splitting, a sample of subcutaneous fat was collected from the grade site area (left half carcass and 12th vertebrae) and stored at -80°C for subsequent fatty acid analysis.

Backfat Fatty Acid Analysis

Backfat samples (50 mg) were freeze-dried and directly methylated with sodium methoxide. FAMEs were analyzed using the GC method outlined by Cruz-Hernandez et al. [10]. The *trans*-18:1 isomers were analyzed using two complementary GC temperature programs [3, 11].

Statistical Analysis

Data were initially analyzed as a one-way ANOVA including diet as the main effect and kill day and pen as random variables using PROC MIXED [12]. Then, pre-planned comparisons of means were conducted (comparisons: **1**: control versus wheat; **2**: control versus corn; **3**: corn versus wheat; **4**: 20% versus 40% corn; **5**: 20% versus 40% wheat). Significance was declared at $P \leq 0.05$.

III. RESULTS AND DISCUSSION

Feed composition (Table 1) revealed interesting differences depending on the DDGS-type included in the ration. Corn DDGS diets had considerably higher fat content (4.4% and 5.4% for 20% and 40%, respectively) in comparison to wheat DDGS (2.9% and 3.5% for 20% and 40%, respectively) and barley-based (2.4%) rations. In terms of FAME composition (percentage basis), wheat DDGS fatty acid profile agreed with other results [7] and, in general, was quite close to the control diet fatty acid profile. However, corn DDGS ration had lower 16:0, *c*11-20:1 and 18:3n-3, but higher 18:0 and *c*9-18:1 in comparison to other rations. Increasing crude fat levels in the diet with addition of DDGS provided increasing levels of linoleic acid (18:2n-6) available for ruminal biohydrogenation.

Replacing barley with DDGS had no effect on total saturated fatty acid (SFA), non-conjugated non-methylene interrupted diene and conjugated linoleic acid (CLA, isomeric profile not reported) contents of backfat tissue (Table 2). On the other hand, significant differences were found for the rest of the fatty acid groups and ratios. Backfat from animals fed the control diet had the highest branched-chain fatty acid (BCFA) content ($P<0.05$), and 20% DDGS showed higher contents than 40% DDGS in both types of grains ($P<0.05$), a result that likely reflects an increase in propionate production in diets with higher levels of readily fermentable barley grain [13].

Total monounsaturated fatty acids (MUFA) were also highest in control animals ($P<0.05$) due to significantly higher levels of *cis*-MUFA. *Trans*-MUFA, however, was highest in corn DDGS fed animals (5.6%; $P<0.001$) compared to animals fed other diets (3.7%). Moreover, animals fed 40% corn DDGS had higher *trans*-MUFA than animals fed 20% corn DDGS (6.2% and 4.9%, respectively; $P<0.01$). Total *trans* fatty acids (*trans*-FA) including *trans*-MUFA plus *c,t*- and *t,t*-dienes, were also highest in corn DDGS fed animals ($P<0.001$), and again, backfat from 40% corn DDGS fed animals showed significantly higher content than 20% corn DDGS (6.9% and 5.5%, respectively; $P<0.01$).

Levels of total PUFA were in agreement with levels of DDGS inclusion in the diet. Animals fed DDGS diets had significantly higher PUFA (4.4%; $P<0.001$) than control animals (2.2%), while backfat from animals fed 40% DDGS was also higher than 20% DDGS for both grains (4.8% vs 4.0% in corn; $P<0.001$, and 5.1% vs 3.8% in wheat; $P<0.001$). The differences reported for PUFA were also applicable to n-6 content. The n-3 content was, however, significantly higher in backfat from animals fed wheat DDGS (0.5%) compared to other diets (0.3%; $P<0.001$). Furthermore, backfat from 40% wheat DDGS fed animals had the highest overall n-3 content (0.6%; $P<0.001$). Aforementioned differences reported for PUFA were reflected in the n-6/n-3 and P/S ratios. Backfat from corn DDGS fed animals had the highest n-6/n-3 ratio (11.8), with the highest level found when feeding 40% corn DDGS (13.5; $P<0.001$), and control animals the lowest (6.0), while wheat DDGS fed animals showed intermediate values (8.2). P/S ratio was highest in DDGS fed animals (0.11), particularly in 40% DDGS (0.12; $P<0.001$), while control animals had the lowest value (0.05).

Backfat from corn DDGS fed animals had higher total and individual *trans*-18:1 (6*t*/8*t*-, 9*t*-, 10*t*-, 11*t*-, 12*t*-, 13*t*/14*t*-) compared to backfat from other dietary treatments (Table 3; $P<0.001$) with the highest level found in 40% corn DDGS fed animals ($P<0.001$). Other differences ($P<0.05$) were also observed in some minor isomers (4*t*-, 5*t*-, 15*t*-, 16*t*-) and these were, in general, higher in corn DDGS fed animals compared to control animals.

Of the individual *trans*-18:1 isomers detected, 10*t*- and 11*t*- together represented from 62% (40% DDGS) to 71% (control) of the total *trans*-18:1. As such, the relative flow of PUFA through the major biohydrogenation pathways (i.e., 10*t*- or 11*t*-18:1) can be judged by the 11*t*-/10*t*-18:1 ratio with a higher ratio denoting an improvement for consumers. In backfat, when feeding corn DDGS there was a significantly lower 11*t*-/10*t*-18:1 ratio in comparison to wheat DDGS ($P<0.01$) and control diets ($P<0.05$). This is also related to the fact animals from the wheat DDGS ration had the lowest content of 10*t*-18:1.

IV. CONCLUSION

Backfat levels of total SFA, CLA and dienes were unaffected by substituting barley with corn or wheat DDGS. MUFA were higher in control samples while PUFA were higher in DDGS samples. Overall, backfat from control (barley-based) and wheat DDGS fed animals had lower *trans*-18:1 content and consequently lower levels of individual *trans*-18:1 isomers and an improved (higher) 11*t*-/10*t*-ratio compared to backfat from corn DDGS fed animals.

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Table 1
Total fatty acid methyl ester (FAME) and fatty acid composition of experimental diets

		20% DDGS		40% DDGS	
Feed Composition	**Control**	**Corn**	**Wheat**	**Corn**	**Wheat**
FAME (mg/g feed[*])	24.2	44.3	29.2	54.1	35.4
Fatty acid (% of total FAME)					
16:0	18.5	16.2	19.0	15.6	18.7
18:0	1.66	1.75	1.58	1.78	1.53
9*c*-18:1	18.0	21.7	17.3	22.8	17.9
11*c*-18:1	1.32	0.80	1.00	0.78	1.08
18:2n-6	51.3	54.4	53.5	54.5	53.1
20:0	0.34	0.37	0.28	0.38	0.26
11*c*-20:1	0.99	0.50	0.79	0.44	0.77
18:3n-3	7.03	3.73	5.84	3.16	6.04
20:2n-6	0.10	0.08	0.10	0.07	0.11
22:0	0.37	0.26	0.30	0.24	0.28
24:0	0.34	0.33	0.30	0.31	0.28

DDGS: Dried distillers' grains with solubles.
[*]Dry matter basis.

Table 2
Fatty acid composition (groups and ratios) of backfat tissue from steers fed different diets

	Treatments											
		20% DDGS		40% DDGS				Contrasts[z]				
	Control	**Corn**	**Wheat**	**Corn**	**Wheat**	**SEM**	**Sign.**	**1**	**2**	**3**	**4**	**5**
SFA	41.8	41.3	40.9	41.4	41.7	0.626	ns	ns	ns	ns	ns	ns
BCFA	1.63^{a}	1.56^{a}	1.58^{a}	1.34^{b}	1.42^{b}	0.049	**	*	**	ns	**	*
cis-MUFA	48.7^{a}	46.5^{b}	48.1^{ab}	44.3^{c}	46.6^{b}	0.731	***	ns	***	**	*	ns
trans-MUFA	3.96^{c}	4.89^{b}	3.82^{c}	6.25^{a}	3.46^{c}	0.289	***	ns	***	***	**	ns
MUFA	52.6^{a}	51.4^{abc}	52.0^{ab}	50.6^{bc}	50.0^{c}	0.618	*	*	*	ns	ns	*
trans-FA	4.60^{c}	5.52^{b}	4.47^{c}	6.94^{a}	4.10^{c}	0.303	***	ns	***	***	**	ns
PUFA	2.22^{c}	3.96^{b}	3.82^{b}	4.84^{a}	5.14^{a}	0.152	***	***	***	ns	***	***
n-6	1.90^{c}	3.60^{b}	3.39^{b}	4.50^{a}	4.59^{a}	0.143	***	***	***	ns	***	***
n-3	0.32^{c}	0.36^{c}	0.43^{b}	0.33^{c}	0.55^{a}	0.016	***	***	ns	***	ns	***
CLA	0.82	0.88	0.88	0.97	0.81	0.042	ns	ns	ns	ns	ns	ns
t,t; *c,t* & *c,c* dienes	0.73	0.69	0.73	0.73	0.72	0.027	ns	ns	ns	ns	ns	ns
n-6/n-3	5.97^{d}	10.0^{b}	7.95^{c}	13.5^{a}	8.40^{c}	0.558	***	**	***	***	***	ns
P/S	0.05^{c}	0.10^{b}	0.09^{b}	0.12^{a}	0.12^{a}	0.004	***	***	***	ns	***	***

DDGS: Dried distillers' grains with solubles; SFA: saturated fatty acids; BCFA: branched-chain fatty acids; MUFA: mono-unsaturated fatty acids; *trans*-FA: *trans*-MUFA plus *t,t*- and *c,t*-dienes; PUFA: polyunsaturated fatty acids, CLA: conjugated linoleic acids; P/S: PUFA/SFA.
[z] Significances for contrasts of **1**: control versus wheat; **2**: control versus corn; **3**: corn versus wheat; **4**: 20% versus 40% corn; **5**: 20% versus 40% wheat.
ns: $P>0.05$; *: $P<0.05$; **: $P<0.01$; ***: $P<0.001$.

Table 3
Trans-18:1 isomeric profile of backfat tissue from steers fed different diets

	Treatments							**Contrasts**[z]				
		20% DDGS		**40% DDGS**								
	Control	**Corn**	**Wheat**	**Corn**	**Wheat**	**SEM**	**Sign.**	**1**	**2**	**3**	**4**	**5**
4*t*-18:1	0.009	0.009	0.012	0.014	0.011	0.002	ns	ns	ns	ns	*	ns
5*t*-18:1	0.010	0.012	0.013	0.015	0.012	0.002	ns	ns	ns	ns	ns	ns
6*t*/7*t*/8*t*-18:1	0.172^{c}	0.307^{b}	0.215^{c}	0.465^{a}	0.218^{c}	0.027	***	ns	***	***	***	ns
9*t*-18:1	0.226^{c}	0.340^{b}	0.261^{c}	0.440^{a}	0.261^{c}	0.022	***	ns	***	***	**	ns
10*t*-18:1	2.021^{bc}	2.372^{b}	1.595^{cd}	3.163^{a}	1.326^{d}	0.191	***	*	**	***	**	ns
11*t*-18:1	0.646^{c}	0.776^{b}	0.742^{bc}	0.919^{a}	0.690^{bc}	0.045	**	ns	**	**	*	ns
12*t*-18:1	0.157^{c}	0.209^{b}	0.174^{bc}	0.276^{a}	0.171^{c}	0.013	***	ns	***	***	**	ns
13*t*/14*t*-18:1	0.254^{c}	0.318^{b}	0.281^{bc}	0.400^{a}	0.273^{bc}	0.018	***	ns	***	***	**	ns
15*t*-18:1	0.164	0.196	0.191	0.206	0.183	0.022	ns	ns	*	ns	ns	ns
16*t*-18:1	0.104	0.121	0.132	0.129	0.122	0.008	ns	*	*	ns	ns	ns
***trans*-18:1**	3.760^{c}	4.674^{b}	3.607^{c}	6.014^{a}	3.270^{c}	0.283	***	ns	***	***	**	ns
11*t*-/10*t*-	0.540	0.366	0.541	0.337	0.575	0.077	ns	ns	*	**	ns	ns

DDGS: Dried distillers' grains with solubles.
[z] Significances for contrasts of **1**: control versus wheat; **2**: control versus corn; **3**: corn versus wheat; **4**: 20% versus 40% corn; **5**: 20% versus 40% wheat.
ns: P>0.05; *: P<0.05; **: P<0.01; ***: P<0.001.