PE9.39 Fatty acid composition of north American beef: backfat 337.00

Noelia Aldai (1) noelia.aldai@agr.gc.ca, JKG Kramer(2), MER Dugan (1)
(1)Lacombe Research Centre, Agriculture and Agri-Food Canada, Lacombe, AB, Canada
(2)Guelph Food Research Centre, Agriculture and Agri-Food Canada, Guelph, ON, Canada

***Abstract*—A survey of Canadian and US retail beef was undertaken with emphasis on the *trans* fatty acid (*trans* FA) and conjugated linoleic acid (CLA) isomers. Thirty striploin steaks were purchased in retail stores in both Kitchener/Waterloo, Ontario and Cleveland, Ohio. Backfat and *longissimus lumborum* muscle of steaks were analysed separately, but only backfat is reported. Total SFA and *trans* FA were higher in US, while total *cis*-MUFA and branch-chain FA were higher in Canadian backfat. There were no differences in the polyunsaturated FA content or the n-6/n-3 ratio. Average *trans* FA content in backfat ranged from 2.2 to 12.8% with 10*t*-18:1 predominating in both US (53% of total *trans*-18:1) and Canadian (50%) samples, followed by vaccenic acid (11*t*-18:1) present at 15% and 17% of total *trans*-18:1, respectively. Total *trans* FA in backfat was associated with increased levels of the 10*t* isomer. CLA content ranged from 0.28 to 0.91% with rumenic acid (9*c*,11*t*-18:2) predominating in both US (50% of total CLA) and Canadian (57%) samples. Appreciable amounts of 9*t*,11*c*-, 10*t*,12*c*- and 7*t*,9*c*-CLA were observed in most backfat samples ranging from 0.05-0.39% of total fat, or averaging 34 and 29% of total CLA in US and Canadian samples, respectively. The highest levels of total CLA in backfat were associated with higher levels of 9*c*,11*t*-18:2. Current beef fat in Ontario and Ohio are rich in 10*t*-18:1 and contain considerable non-rumenic acid CLA isomers.**

JKG Kramer (corresponding author; phone: +1-519-780-8044; fax: +1-519-829-2600; e-mail: kramerj@agr.gc.ca).

***Index Terms*—survey, beef, CLA, *trans* FA, vaccenic acid.**

I. INTRODUCTION

THE fat content and fatty acid (FA) composition of beef are major indicators of quality and nutritional value [1]. Current recommendations for human health in many countries intend to reduce levels of total fat (< 15-30%), saturated fatty acids (SFA) (< 10%, particularly limiting the intake of 14:0 and 16:0), and n-6 polyunsaturated fatty acids (PUFA) (< 5-8%), and increase the intake of n-3 PUFAs (> 1-2%) of total energy intake to maintain a n-6/n-3 ratio of < 5:1, and a P/S ratio above 0.4 [2]. Some countries have introduced mandatory labelling of total *trans* FA in foods, which includes all *trans* FA with isolated double bonds, but excludes conjugated linoleic acid (CLA) [3]. Consequently, some healthy *trans* FA isomers may be included in the total *trans* FA label (i.e., vaccenic acid; 11*t*-18:1), while all CLA isomers, whether healthy (i.e., rumenic acid; 9*c*,11*t*-18:2) or otherwise, are excluded. This has important implications in beef. In the Danish regulations, all ruminant products are excluded [3] on the assumption that ruminants fats consist mainly of vaccenic and rumenic acids with demonstrated health effects [4,5]. However, several reports are now showing that the *trans* FA and CLA isomers in ruminant products can be altered depending mainly on the diet fed, resulting in increased levels of total *trans* FA, specifically 10*t*-18:1 [6,7]. Increased levels of 10*t*-18:1 were found in finished beef [8], and this isomer was reported to be atherogenic in animal models [9,10] and in humans [11].

Surveys of the FA composition of Canadian [12,13,14] and US beef products [15] are limited, specifically related to the *trans*-18:1 and CLA isomers. The present survey was undertaken to evaluate and compare the FA composition of retail beef available in eastern Canada and US. Backfat was selected because it reflects the isomer profile present in meat lipids [14,16].

II. MATERIALS AND METHODS

Sample Collection and Fatty Acid Analysis

Striploin steaks from Canada (n = 30) and US (n = 30) A/AA Grade (youthful) beef were collected on separate weekends in March 2007, from seven different grocery chains and individual outlets; one steak was collected per store per location. Production details for beef sampled are unknown. All samples were stored on ice in insulated picnic coolers and transported to the laboratory for FA analysis.

From the striploin steak 5g of backfat was sampled from the mid-point of the steak and stored separately at -80 ºC.

Backfat (50mg) was freeze-dried and directly methylated with $NaOCH_3$/methanol [17]. The FA methyl esters were analyzed using two complementary GC temperature programs [18], and Ag^+-HPLC for the CLA isomer determination [17].

The FA composition data for backfat (%) were analyzed as a one-way ANOVA with collection place as the main effect using PROC MIXED [19]. Trend was declared at $P \leq 0.1$ and significance was declared at $P < 0.05$.

III. RESULTS AND DISCUSSION

The backfat FA composition at both locations is presented in Table 1. Total SFAs were significantly higher in US than Canadian backfat ($P < 0.01$), mainly attributed to differences in 16:0 (range 19.6-28.8%) and 18:0 (range 6.6-22.4%). As Ohio finishes very few beef, US beef is likely finished in a more moderate climate than Canadian beef and differences in SFA may relate to climatic differences. Samples were collected from animals finished over the winter and colder temperatures increase Δ^9-desaturase activity converting SFA to monounsaturated fatty acids (MUFA) required to maintain fat in a fluid state [20]. It may increase rates of digesta passage from the rumen [21] thus limiting time available for biohydrogenation of PUFA to SFA. The total SFA content in the eastern Canadian beef fat (42.3%) was in agreement with that found in a parallel study conducted during the winter in western Canada (Calgary, AB; 41.8%), but significantly lower than samples collected in summer [14]. On the other hand, the total SFA content of US beef fat (46.2%) showed greater similarity to results obtained from the summer collection in Calgary (44.2%). The branched-chain fatty acids (BCFA) were significantly higher ($P < 0.05$) in Canadian than in the US samples, specifically the *iso*- and *anteiso*-17:0.

Total *cis*-MUFAs ($P < 0.01$) were significantly higher in Canadian (48.9%) than US backfat (43.5%; $P < 0.01$), mainly attributed to higher levels of 9*c*-18:1. Again these differences could be related to the aforementioned climatic differences noted for SFA. The total *trans*-MUFA content was higher in the US (6.68%) than the Canadian (4.99%; $P < 0.01$) beef fat, due mainly to 6*t*-8*t* to 12*t*-18:1 (Table 2) and both appeared to be higher than previously reported for backfat from western Canada (Calgary, AB; 2.5-3%) [14]. The total of 10*t*- plus 11*t*-18:1 accounted for 46 to 83% of the total *trans*-18:1 content. Higher levels of total *trans*-18:1 were associated with higher levels of 10*t*-18:1, and not vaccenic acid (11*t*-18:1; Figure 1). Of the 60 samples collected, all but 7 had higher 10*t*- than 11*t*-18:1. However, even at the highest levels of total *trans*-18:1 and 10*t*-18:1, the 11*t*-18:1 was never totally absent (5 to 42% of total *trans*-18:1), suggesting that the production of this isomer appears independent of diet and the 10*t* shift.

Across both locations, the total *trans*-18:1 ranged from 2.2 to 12.8%. This high variability in total *trans*-18:1 content may be due to several factors including individual animal variation combined with differences in production systems and management practices (i.e., age/live weight at slaughter, genetics, feeding strategies, usage of antibiotics) [22-25]. The major isomer 10*t*-18:1 was three-fold greater than the second most abundant isomer 11*t*-18:1, and the 10*t*/11*t*-18:1 ratio (Canada 2.98; US 3.45) of all samples ranged from 0.28 to 14.3. High 10*t*/11*t*-18:1ratios were also observed in similar surveys conducted in the US on raw strip steaks (11.7; [15]), and on striploin steaks in Alberta (3.95 and 2.2; [14]), as well as in beef cattle finished on a 73% barley grain diet (2.9; [25]).

Backfat PUFA composition and calculated ratios (P/S, n-6/n-3) from both regions are presented in Table 1. There were no significant differences in the total and n-6 PUFA content, but the total n-3 PUFA levels were higher in Canada. The n-6/n-3 ratio was rather high for both data sets with a slightly improved ratio for Canadian steaks. Backfat is generally not a good source of PUFA which is also reflected in the low P/S ratio (Table 1).

There were no significant differences in the CLA content between the two locations. The total CLA averaged 0.56 ± 0.03% in US and 0.60 ± 0.03% in Canadian steaks, with a range from 0.28 to 0.91% across both locations. The major CLA isomer was 9*c*,11*t*-18:2 (0.28% in US and 0.35% in Canadian steaks, range across all samples was 0.08 to 0.71%) followed by 7*t*,9*c*-18:2 (about 0.10% in both sets, ranged from 0.04 to 0.23%). Significant amounts of 9*t*,11*c*- (range 0.003 to 0.11%) and 10*t*,12*c*-18:2 (range 0.002 to 0.11%) were also found. In general, the total CLA content (%) was associated with higher levels of the major 9*c*,11*t*-18:2 isomer, and not the sum of the other major CLA isomer (7*t*,9*c*-, 9*t*,11*c*- and 10*t*,12*c*-18:2) as shown in Figure 2. Similar results were observed for total and individual CLA isomers in a companion study conducted on retail steaks purchased in western Canada (Calgary, AB) [14]. In

a previously reported US survey the individual CLA isomers were not analyzed [15]. Increased levels of CLA isomers other than 9*c*,11*t*-18:2 are generally not observed in beef produced in Europe [22,26,27] and may relate to higher dietary forage levels in Europe and the use of antibiotics as growth promotants in North America.

IV. CONCLUSION

To our knowledge, this is the first report of a detailed *trans*-18:1 and CLA composition of retail beef obtained in eastern Canada and the USA. It is well known that beef fat, in general, does not meet dietary guidelines for humans regardless of animal production practices and this is mainly because of the high SFA content and the low P/S ratio. However, 18:0 makes up a substantial portion of SFA in beef which has a neutral effect on human plasma cholesterol levels. Beef can also be a source of vaccenic and rumenic acids. But it was evident from this survey that there is a need to improve the *trans* FA and CLA composition of North American beef, specifically to target a reduction of 10*t*-18:1 and increase both rumenic and vaccenic acids.

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Table 1
Fatty acid composition (groups and ratios) of backfat from USA and Canada

Fatty acid (%)	USA	SEM	Canada	SEM	Sign.
SFA	46.2	0.85	42.3	0.72	**
BCFA	1.22	0.05	1.37	0.06	*
***cis*-MUFA**	43.5	1.20	48.9	1.04	**
***trans*-MUFA**	6.87	0.47	4.99	0.43	**
PUFA	1.90	0.07	2.14	0.17	ns
n-6	1.75	0.07	1.93	0.17	ns
n-3	0.14	0.01	0.20	0.01	**
n-6/n-3	13.8	0.94	11.0	1.63	ns
P/S	0.04	0.002	0.05	0.004	*

ns: $P > 0.1$; +, $P < 0.1$, *: $P < 0.05$; **: $P < 0.01$; ***: $P < 0.001$. SEM: standard error of the mean.
SFA: saturated fatty acids; BCFA: branched-chain fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids, CLA: conjugated linoleic acids; P/S: PUFA/SFA.

Table 2
Trans-18:1 and conjugated linoleic acid isomeric profile of backfat from USA and Canada

Fatty acid (%)	USA	SEM	Canada	SEM	Sign.
4*t*-18:1	0.020	0.001	0.010	0.001	***
5*t*-18:1	0.024	0.001	0.015	0.001	***
6*t*/7*t*/8*t*-18:1	0.61	0.04	0.37	0.04	***
9*t*-18:1	0.63	0.03	0.39	0.03	***
10*t*-18:1	3.55	0.40	2.47	0.37	+
11*t*-18:1	1.03	0.08	0.83	0.09	+
12*t*-18:1	0.29	0.02	0.23	0.02	*
13*t*/14*t*-18:1	0.31	0.03	0.33	0.03	ns
15*t*-18:1	0.18	0.01	0.12	0.01	***
16*t*-18:1	0.12	0.01	0.14	0.01	+
***trans*-18:1**	6.76	0.47	4.91	0.43	**
10*t*-/11*t*-18:1	3.45	0.58	2.98	0.63	ns
9*c*,11*t*-18:2	0.284	0.0215	0.346	0.0299	ns
9*t*,11*c*-18:2	0.047	0.0040	0.053	0.0037	ns
8*t*,10*c*-18:2	0.005	0.0005	0.002	0.0002	***
7*t*,9*c*-18:2	0.107	0.0072	0.098	0.0099	ns
11*t*,13*c*-18:2	0.009	0.0015	0.007	0.0012	ns
11*c*,13*t*-18:2	0.008	0.0015	0.008	0.0006	ns
10*t*,12*c*-18:2	0.040	0.0046	0.026	0.0045	*
CLA	0.563	0.0258	0.603	0.0293	ns

ns: $P > 0.1$; +, $P < 0.1$, *: $P < 0.05$; **: $P < 0.01$; ***: $P < 0.001$. SEM: standard error of the mean.

Figure 1
Relative abundance of 10*t*- and 11*t*-18:1 as percent of total lipids after sorting all backfat samples in increasing order of total *trans*-18:1 (n = 60)

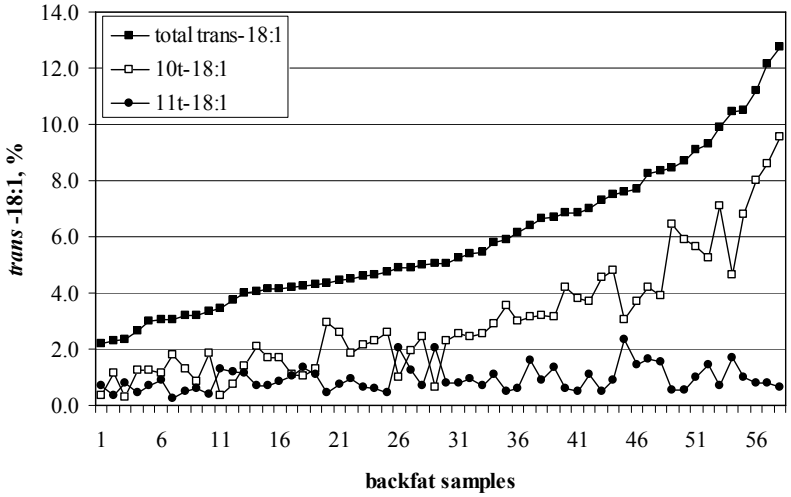
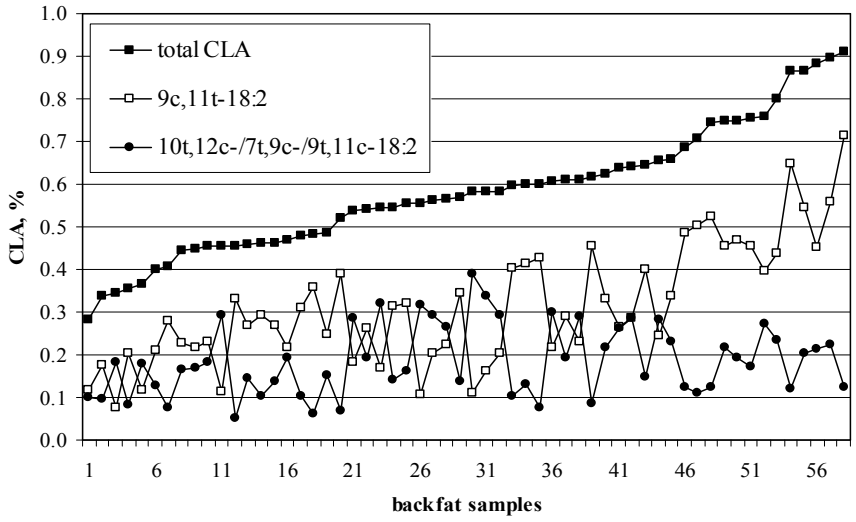


Figure 2



Relative abundance of 9*c*,11*t*-18:2 and 10*t*,12*c*-/7*t*,9*c*-/9*t*,11*c*-18:2 as percent of total lipids after sorting all backfat samples in increasing order of total CLA (n = 60)