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Effects of diets supplemented with sunflower or flax seeds on quality and fatty acid profile of hamburgers made with perirenal or subcutaneous fat

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ABSTRACT

Steers were fed grass hay or red clover silage based diets containing flaxseed or sunflower seed as sources of 18:3n − 3 and 18:2n − 6 respectively. Hamburgers were made from *triceps brachii* and perirenal or subcutaneous fat. Perirenal-hamburgers contained more polyunsaturated fatty acids (PUFA), several PUFA biohydrogenation intermediates (BHI), and 18:0 ($P < 0.05$). Oxidative stability was similar across hamburgers ($P > 0.05$). Sensory differences were found due to hamburger fat source, but were < one panel unit. Within perirenal-hamburgers, feeding flaxseed increased 18:3n − 3 and its BHI ($P < 0.05$), and feeding sunflower seed increased 18:2n − 6 and its BHI ($P < 0.05$). Feeding flaxseed increased off-flavour intensity and oxidation in perirenal-hamburgers ($P < 0.05$). Feeding oilseeds in forage based diets while using perirenal fat to make hamburgers provides opportunities to increase PUFA and BHI with potential to impact human health, but control measures need to be explored to limit oxidation and off-flavours when feeding flaxseed.

1. Introduction

Per capita hamburger consumption in the USA has remained consistent at 42% of total beef consumption since 1980 (NCBA, 2013), representing an opportunity through which to address health concerns regarding beef fatty acid profiles and market value-added beef products. Hamburger is made with lean trim and lower value lean cuts combined with fat trim typically of subcutaneous origin. Variation in the fatty acid profile of subcutaneous adipose tissue across anatomical locations has prompted the suggestion of selecting adipose tissues based on location to maximise the monounsaturated fatty acid (MUFA)/saturated fatty acid (SFA) ratio of hamburger (Turk & Smith, 2009). Efforts to enhance the nutritive quality of meat products have also focused on increasing the content of polyunsaturated fatty acids (PUFA), particularly omega-3 (n − 3 FA), due to their positive effects on human health (FAO, 2010; Smit, Mozaffarian, & Willett, 2009) and opportunities for enrichment claims at the retail level (Turner et al., 2014). Along with PUFA, enrichment of their biohydrogenation intermediates (BHI) such as conjugated linoleic acid (CLA) have been goals for the beef industry due to discoveries that they may have roles in the prevention or treatment of diseases ranging from cancer to cardiovascular disease (Gebauer et al., 2011; Mapiye et al., 2012). The best approach for enriching beneficial fatty acids in beef and beef products is still, however, a matter of current investigation.

Diet is the most influential factor affecting beef fatty acid composition (Raes, De Smet, & Demeyer, 2004). Increasing the amount of PUFA in beef can be challenging as PUFA are toxic to rumen microbes, and are rapidly detoxified through biohydrogenation (Maia et al., 2010). The composition and content of BHI deposited in beef depends on the amount and source of PUFA in the diet, and interactions with remaining dietary components and the microbial population (Dugan, Aldai, Aalhus, Rolland, & Kramer, 2011; Lourenço, Ramos-Morales, & Wallace, 2010; Shingfield, Bonnet, & Scollan, 2013). Recently Mapiye, Aalhus, et al. (2013) demonstrated feeding red clover silage or grass hay based diets combined with either sunflower seed or flaxseed supplementation can substantially enrich PUFA and PUFA-BHI in beef. To further increase amounts of PUFA-BHI in beef products with added fat such as hamburger, perirenal fat as opposed to subcutaneous fat may be utilized as it contains greater proportions of some BHI (ex. *trans (t)*-18:1 isomers) compared to subcutaneous tissue (Jiang et al., 2013), but preferential deposition of other BHI have not been fully characterised.

Abbreviations: AD, atypical dienes; BHI, biohydrogenation intermediates; BCFA, branched chain fatty acids; *c*, *cis*; CLA, conjugated linoleic acid; CLnA, conjugated linolenic acid; HDL-C, high density lipoprotein-cholesterol; DM, dry matter; LDL-C, low density lipoprotein-cholesterol; MUFA, monounsaturated fatty acid; PPAR, peroxisome proliferator activated receptor; PUFA, polyunsaturated fatty acid; SFA, saturated fatty acids; *TBARS, thiobarbituric acid reactive substances*; *t*, *trans*.

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The present research was conducted as a companion study to Mapiye, Aalhus, et al. (2013) where steers were fed grass hay or red clover silage based diets supplemented with either flaxseed or sunflower seed. Specific objectives for the present study were to compare the palatability, retail display characteristics and fatty acid profiles of hamburger produced with subcutaneous or perirenal fat, and within perirenal hamburgers, to examine the potential for animal diet to further influence these parameters.

2. Materials and methods

2.1. Animals and diets

Tissues used were collected from the Mapiye, Aalhus, et al. (2013) study where 64 British × Continental cross bred steers were divided among four dietary treatments with two pens of eight steers per treatment. Briefly, diets consisting of 70% (dry matter, DM) red clover silage or grass hay, were blended with whole sunflower seed or triple rolled flaxseed to supply 5.4% added oil to the diets (Table 1). Diets included a premix to meet vitamin and mineral requirements, except vitamin E which was included in the premix in excess of requirements (3222 IU/kg) due to its positive effects on the *trans*-18:1 profile (Juarez et al., 2010; Mapiye et al., 2012). Steers had free access to feed and water and were slaughtered at an average of 205 d on feed. Steers were raised and slaughtered in accordance with guidelines established by the CCAC (1993). One animal from the grass hay-flaxseed diet was removed from the trial for reasons unrelated to the diet.

Table 1
Nutrient and fatty acid composition of the experimental diets.

Variable	Grass hay		Red clover silage	
	Flaxseed	Sunflower	Flaxseed	Sunflower
Diet ingredients (% DM basis)				
Red clover silage	0	0	70	70
Grass hay	70	70	0	0
Barley straw	11.5	0	11.5	0
Sunflower-seed	0	18.4	0	18.4
Flaxseed	14.3	0	14.3	0
Vitamin/mineral supplement[a]	4.2	4.2	4.2	4.2
Barley grain	0	7.4	0	7.4
Nutrient composition (DM basis)				
Dry matter (%)	93.1	93	46.9	46.9
Crude protein (%)	13.3	13.4	14.2	14.0
Metabolizable energy[b] (Mcal/kg)	1.71	1.66	1.77	1.72
Crude fat (%)	6.4	6.6	8.2	8.4
Calcium (%)	1.1	1.1	1.1	1.2
Phosphorus (%)	0.3	0.3	0.3	0.2
ADF (%)	44.3	45.4	43	44
NDF (%)	53.2	57.6	55.5	61.6
Fatty acid (% of total fatty acids)				
14:0	0.2	0.2	0.1	0.1
16:0	8.6	10.2	7.5	8.4
18:0	3	4.1	2.9	4.2
20:0	0.4	0.5	0.3	0.4
22:0	0.7	0.9	0.4	0.8
24:0	0.6	0.5	0.4	0.4
*c*9-18:1	11.6	11.3	11.6	11.7
*c*11-18:1	0.8	0.9	0.8	0.7
18:2n−6	23.4	66	21.4	70.4
18:3n−3	50.7	5.3	54.6	2.8

[a] Vitamin/mineral supplement per kg DM contained 1.86% calcium, 0.93% phosphorous, 0.56% potassium, 0.21% sulphur, 0.33% magnesium 0.92% sodium, 265 ppm iron, 314 ppm manganese, 156 ppm copper, 517 ppm zinc, 10.05 ppm iodine, 5.04 ppm cobalt, 2.98 ppm selenium, 49722 IU/kg vitamin A, 9944 IU/kg vitamin D3, and 3222 IU/kg vitamin E.

[b] Total digestible nutrients were calculated based on ADF content according to Bull (1981), and from this metabolizable energy was calculated according to NRC (1996).

2.2. Sample collection

At slaughter, perirenal fat was collected, vacuum packed and held in a 2 °C cooler. Carcasses were chilled 24 h under the same conditions prior to collection and vacuum packing of *triceps brachii* muscle and subcutaneous fat from along the dorsal region. After 6 d storage, sources of lean and fat were ground (80:20 w/w) initially through a 6 mm plate, mixed and then ground through a 4 mm plate (Butcher Boy meat grinder Model TCA22, Lasar Manufacturing Co, Los Angeles, CA, USA). A 50 g subsample of each grind was collected for 0 d thiobarbituric acid reactive substances (TBARS) determination (Nielsen, Sorensen, Skibsted, & Bertelsen, 1997). A second 50 g sample was comminuted using a Robot Coupe Blixir BX3 food processor (Robot Coupe USA Inc., Ridgeland, MS, USA) and frozen at −80 °C for subsequent fatty acid analysis. Three 140 g hamburger patties (11.4 cm diameter × 0.63 cm thick) were formed from remaining grind using a single hamburger press (Cabelas, Sydney, NE, USA). One patty was placed on a polystyrene tray, over-wrapped with an oxygen permeable polyvinylchloride film (oxygen transmission rate 8000 ml per m^2 per 24 h; Vitafilm Choice Wrap, Goodyear Canada Inc.) and placed into a fan assisted, horizontal retail display case (Hill Refrigeration of Canada Ltd., Barrie, ON, Canada) with an average temperature of 3.5 °C for retail measurements. Remaining patties were vacuum packaged and stored at −20 °C for subsequent sensory evaluation.

2.3. Retail display

Hamburgers were held under fluorescent room lighting (GE deluxe cool white; General Electric Canada, Oakville, ON, Canada) supplemented with incandescent lighting directly above the display case (GE clear cool beam 150 W/120 V; General Electric Canada) spaced 91.5 cm apart to provide an intensity of 1076 lx at the meat surface for 12 h per d. Objective colour measurements (L*, a*, b*; CIE (1978)) were taken on 0 d and 4 d in triplicate across the surface of each hamburger patty (Minolta CR-300 with Spectra QC-300 Software, illuminant C and 2° observer, 3 mm aperture; Minolta Canada Inc., Mississauga, ON). These values were converted to hue and chroma (hue = $\tan^{-1}(b^*/a^*)$; and chroma = $(a^{*2} + b^{*2})^{0.5}$) and averaged within day. Spectral reflectance readings were also collected at the same time in order to calculate relative contents of metmyoglobin and oxymyoglobin (Krzywicki, 1979). On 4 d, following objective colour measurements, TBARS were measured for a second time. Changes between 0 and 4 d values for L*, hue, chroma, metmyoglobin, oxymyoglobin and TBARS were used to detect differences between treatments.

2.4. Sensory evaluation

Prior to sensory evaluation, hamburgers were placed on a tray in a single layer and thawed overnight at 4 °C. Hamburgers were weighed prior to cooking, and then cooked in individual non-stick pans on an electric grill (Garland Grill ED30B, Condon Barr Food Equipment Ltd., Edmonton, AB) pre-heated to 205 °C. Previous testing indicated formed hamburger patties reached an internal temperature of 71 °C with juices running clear after cooking for 4 min on one side, flipping and then cooking an additional 8 min. Following cooking to 71 °C, hamburgers were cooled for 2 min at room temperature and then final weights were recorded. Hamburgers were divided into eight equal wedges and presented to eight panellists trained according to the American Meat Science Association research guidelines (AMSA, 1995). Panellists evaluated six samples per session and attended four sessions per day with the experimental treatments randomized amongst these sessions. Attribute ratings were electronically collected (Compusense Inc., Guelph, On, Canada) using a nine point descriptive scale for initial and overall tenderness (9 = extremely tender; 1 = extremely tough), initial and sustainable juiciness (9 = extremely juicy; 1 = extremely dry), beef flavour intensity (9 = extremely intense; 1 = extremely bland/none),