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Effect of dietary inclusion of triticale dried distillers' grain and oilseeds on quality and fatty acid profile of meat from feedlot steers

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ABSTRACT

This study compared carcass, meat quality and fatty acid profiles of *longissimus thoracis* (LT) from feedlot cattle fed barley grain with or without oilseed (OS). Six diets containing no oilseed (No-OS), 10% ground flaxseed (FS), 10% high oleate sunflower seeds (SS) with or without 30% triticale dried distiller's grain (DDGS) were prepared. Feeding DDGS increased chroma at 24 and 144 h post mortem. Feeding FS increased weight% of LT PUFA ($P < 0.05$) compared to No-OS or SS. An OS by DDGS interaction occurred for 18:3n − 3 ($P < 0.05$) where FS increased weight% of 18:3n − 3 ($P < 0.05$), a response accentuated ($P < 0.05$) by DDGS. Feeding DDGS increased weight% of LT 18:2n − 6 ($P < 0.05$), but neither OS nor DDGS affected conjugated linoleic acid (CLA, *t*7,*c*9 & *c*9, *t*11-18:2). Feeding FS increased weight% of n − 3 FA, and both FS and SS increased *t*10-18:1 with no effect on CLA or *t*11-18:1. Combination feeding of DDGS and FS further increased weight% of n − 3 FA and tempered increases in *t*10-18:1 with no effect on CLA or *t*11-18:1. The findings suggest a new strategy to increase beef omega-3 fatty acids efficiently through inclusion of a combination of DDGS and FS in feedlot diet.

1. Introduction

Fatty acid profile plays a key role in determining the health properties of beef, with long chain omega-3 (or n − 3) fatty acids being linked to the prevention of coronary artery disease, hypertension, arthritis, diabetes, cancer and inflammatory and autoimmune disorders (Delgado-Lista, Perez-Martinez, Lopez-Miranda, & Perez-Jimenez, 2012; Simopoulos, 1999). Consumers appear willing to pay more for beef that possesses a healthier fatty acid profile (Lusk & Parker, 2009), making studies on increasing the n − 3 fatty acid profile of beef particularly relevant. However, biohydrogenation of unsaturated fatty acids by rumen bacteria makes the generation of predictable fatty acid profiles in meat through diet formulation challenging. For example, 85–100% of dietary alpha-linolenic acid (ALA) is biohydrogenated resulting in poor assimilation of this fatty acid into beef products (Doreau & Ferlay, 1994; Wood et al., 2008). However, recent studies in our group (He, McAllister, et al., 2012; He, Sultana, et al., 2012; He, Yang, et al., 2012; Nassu et al., 2011) and by others (Kronberg, Barceló-Coblijn, Shin, Lee, & Murphy, 2006) have provided insight into approaches that increase n − 3 fatty acids (FA) in beef through the dietary inclusion of high levels of flaxseed (FS, also call linseed; 35% oil) as a major n − 3 FA source high in ALA (55%, n − 3 FA) and relatively low in linoleic acid (LA, 15%, n − 6 FA) and oleic acid (OA, 15%) in combination with dried distiller grains with solubles (DDGS).

Conventional sunflower seeds (SS) contain normally 40% lipids which are high in LA (70%) and low in OA (15%), but in high oleic acid SS amount of OS can account for 60% of total fatty acids. Previous studies using conventional SS found that it increased levels of conjugated linoleic acids (CLA) and vaccenic acid (VA) in beef adipose tissue (Mir, Dugan, He, Entz, & Yip, 2008). These fatty acids arise mainly from rumen biohydrogenation and offer additional health benefits to consumers (Dugan, Aldai, Aalhus, Rolland, & Kramer, 2011; Mir et al., 2003). Compared to conventional SS, inclusion of 14% high oleate SS in a barley grain diet increased backfat thickness in cattle (Gibb et al., 2004). In a comparison of high OA to high LA safflower seed, CLA in various fat and muscle tissues was increased in lambs as compared to control, but the magnitude of this increase was greater for high LA seed (Bolte, Hess, Means, Moss, & Rule, 2002). In feedlot cattle, inclusion of high LA safflower oil increased CLA in adipose tissue more than high OA safflower, but there was no difference in the CLA content of muscle (Hristov, Kennington, McGuire, & Hunt, 2005).

As a product of bioethanol production, DDGS have been used to replace barley grain and barley silage in beef cattle diets. Inclusion of DDGS in beef cattle diets can also increase CLA, VA (Dugan et al., 2010) and ALA whilst decreasing the levels of undesirable *trans* fatty acids in beef (He, Yang, et al., 2012). However, DDGS are not considered a dietary source of n − 3 FA owing to their low levels of ALA and oil. Although the mechanism whereby DDGS alter beef fatty acid composition

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requires further elucidation, it may arise from altered rumen volatile fatty acid profiles, biohydrogenation and/or de novo fatty acid synthesis in adipose tissue. It was hypothesized that inclusion of a combination of FS and DDGS in feedlot diets would further increase beef ALA over FS alone.

Although both feeds can alter the fatty acid composition of meat, neither DDGS (Aldai, Aalhus, et al., 2010; Walter et al., 2010) nor FS (Hernandez-Calva et al., 2011; Maddock et al., 2006) appears to alter carcass or meat quality when included in the diet at moderate levels.

Based on the previous reports, this study was designed to investigate the effects of including triticale DDGS, FS or high oleate SS in the diet on carcass, meat quality and fatty acid profiles of the *longissimus thoracis* (LT) muscle of feedlot cattle.

2. Material and methods

2.1. Diets and feeding experiment

The present study was approved by the Animal Care Committee of Lethbridge Research Centre (LRC), under the auspices of the Canadian Council of Animal Care (CCAC, 1993). Ninety crossbred steers (455 ± 31 kg) were blocked by weight, penned individually and randomly allocated to one of six diets provided *ad libitum* for a period of 15 weeks (n = 15 per diet). Dietary ingredients, nutrient concentration and fatty acid composition are shown in Table 1. When oilseeds (OS) or DDGS was included in the diet, they were substituted for barley grain. Diets included: 1) Barley (control, CON); 2) Barley + DDGS (DDGS); 3) Barley + Flaxseed (FS); 4) Barley + DDGS + FS (FS + DDGS); 5) Barley + SS (SS) and 6) Barley + DDGS + SS (SS + DDGS). The amount of FS and SS in the diet containing DDGS was deliberately reduced by 1.5% to ensure that fat levels in the diet did not exceed 9% of diet DM. The diets fully met or exceeded the NRC recommended nutrient requirements of finishing steers (NRC, 1996). Diets also had similar levels of net energy for maintenance and growth at 1.98–2.15 and 1.33–1.49 Mcal per kg DM, respectively. Information on the growth performance of cattle fed these diets has been reported elsewhere (He, Sultana, et al., 2012).

Table 1
Diet ingredients, nutrient concentration and fatty acid composition.

	No-OS diets		FS-diets		SS-diets	
	CON	DDGS	FS	FS + DDGS	SS	SS + DDGS
Ingredient (% DM)						
Barley	85	55	75	46.5	75	46.5
Barley silage	10	10	10	10	10	10
Flaxseed	0	0	10	8.5	0	0
Sunflower seeds (high oleic)	0	0	0	0	10	8.5
Triticale DDGS	0	30	0	30	0	30
Supplements[a]	5	5	5	5	5	5
Nutrients (% DM)						
Dry matter (%)	73.9	76.2	74.7	76.8	74.5	76.7
Protein (%)	12.7	20.1	13.8	21.0	13.5	20.7
Degradable Carbohydrate (%)	47.6	30.8	42.0	26.0	42.0	26.0
Ether extract (%)	2.7	3.8	7.1	7.6	8.0	8.3
Fatty acid (% total FAME)						
PUFA	59.1	61.6	73.6	71.7	34.9	39.9
18:3 n−3 (ALA)	7.1	5.9	48.6	39.8	1.5	2.0
18:2 n−6 (LA)	52.0	55.7	25.0	31.9	33.4	37.8
MUFA	20.9	21.8	16.4	17.7	55.3	49.8
18:1-*c*9	18.5	19.9	15.4	16.5	54.1	48.5
USFA	80.0	83.4	90.0	89.4	90.2	89.6
SFA	20.0	16.6	10.0	10.6	9.8	10.4
16:0	18.1	14.9	7.5	8.3	6.4	7.3
18:0	1.6	1.6	2.4	2.3	3.4	3.1

DM: dry matter. ADF: acid detergent fibre. NDF: neutral detergent fibre. FAME: fatty acid methyl esters. USFA: unsaturated fatty acids. MUFA: monounsaturated fatty acids. PUFA: polyunsaturated fatty acids.

[a] Supplement was composed of (%): 56.5 barley, 10 canola meal, 2 urea, 25 limestone, 3 salt, 0.066 vitamin E 500, 1 premix, 0.05 flavour and 2.5 molasses. The premix in the supplement provided per kg of diet DM: 15 mg copper, 65 mg zinc, 28 mg manganese, 0.7 mg iodine, 0.2 mg cobalt, 0.3 mg selenium, 6000 IU vitamin A, 600 IU vitamin D and 47 IU vitamin E.

2.2. Carcass quality measurement

Detailed carcass and meat quality data were collected on eight steers per treatment after slaughter at the Lacombe Research Centre of Agriculture and Agri-Food Canada (Lacombe, AB, Canada) on four separate slaughter dates (2 per treatment per slaughter date). The remaining cattle were harvested at Cargill Foods (High River, AB, Canada) on a single day. Carcass quality traits collected at both sites included hot carcass weight, dressing percentage, grade fat, rib eye area, marbling score, quality grade and meat yield as per the Livestock and Poultry Carcass Grading Regulations of the Canadian Food Inspection Agency (CFIA, 1992). Numeric marbling scores were also assessed according to the American Meat Science Association (1990) marbling standards.

At the Lacombe Research Centre, meat quality traits on carcasses from 56 steers (8 per treatment) were further estimated as previously described (Aldai, Aalhus, et al., 2010; Hernandez-Calva et al., 2011). Briefly, carcass pH and temperature were measured within 45 min of slaughter posterior to the grade site on the left LT muscle. Carcasses were then steam pasteurized and railed into a 2 °C cooler with a wind speed of 0.5 m per s for 24 h. Chilled carcass sides were weighed to determine cooler shrink loss. Samples from the left LT muscle were collected and frozen at −35 °C for subsequent fatty acids analyses. The trimmed LT muscle were labelled, vacuum packaged and placed in a cooler at 2 °C with a wind speed of 0.5 m per s for 6 days of ageing.

2.3. Meat quality measurement

Meat quality parameters including shear force, colour and drip loss as well as concentrations of moisture, crude protein and fat were measured following established procedures (Basarab et al., 2006; Hernandez-Calva et al., 2011). After ageing, the left LT was removed from the cooler and steaks (2.5 cm) were removed from the posterior end and used to assess meat quality. The first steak was weighed and a spear point temperature probe (10 cm) was inserted at the midpoint of the steak. Steaks were grilled (Garland Grill ED30B; Condon Barr Food Equipment Ltd., Edmonton, AB) until they reached an internal temperature of 35.5 °C, turned and further cooked to a final internal temperature of 71 °C (Hewlett Packard HP34970A Data Logger; Hewlett Packard Co., Boise ID). Cooked steaks were placed in polyethylene bags, sealed, and cooled via immersion in ice water. Steaks were transferred to a cooler, allowed to stand for 24 h and weighed. Peak shear force was determined on six 1.9 cm-cores removed parallel to the fibre grain using a TA-XT Plus Texture Analyzer (Texture Technologies Corp., Hamilton, MA) equipped with a Warner-Bratzler shear head. The unit possessed a 30 kg load cell operated at a crosshead speed of 20 cm per min. Shear force data were compiled using Texture Exponent 32 Software (Texture Technologies Corp., Hamilton, MA). Fresh steaks were cooled to 4 °C and colour measurements were obtained after 24 h and 144 h post mortem. After a 20 min period of exposure to atmospheric oxygen, objective colour measurements including CIE L* (brightness), a* (red–green axis), b* (yellow–blue axis) were taken in triplicate across the surface of each steak and averaged (Minolta CR-300 with Spectra QC-300 Software, illuminant C and 2° observer, 3 mm aperture; Minolta Canada Inc., Mississauga, ON). To determine drip loss, the steak was pre-weighed into a polystyrene tray with a dri-loc pad, over-wrapped with oxygen permeable film and stored for 5 days at 1 °C. For chemical analysis, the remaining LT was then trimmed of all overlying connective tissue and ground three times using a Butcher Boy Meat Grinder with a 2 mm grind plate (Model TCA22, Lasar Manufacturing Co., Los Angeles, CA). Concentration of moisture was estimated by drying the remaining sample. The dried meat sample was further ground (Grindomix Model GM200; Retsch