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Effect of supplementation of beef steer diets with oil containing n6 and n3 fatty acids and 48 h feed withdrawal treatments on animal productivity, carcass characteristics and fatty acid composition

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ABSTRACT

A 2×3 factorial experiment was conducted with 72 weanling (about 180 d old), crossbred steers (with Hereford, Angus and Charolais genetics and initial body weight of 280.5±5.8 kg) to determine the effect of dietary supplementation with a 50/50 mixture of flax and sunflower oils at 5% of diet, to steers in three feed withdrawal (FW) treatments on production factors, carcass characteristics, adipocyte marker; peroxisome proliferator activated receptor γ (PPARγ) RNA expression and fatty acid composition of muscle (*Pars costalis diaphragmatis*; PCD) and subcutaneous fat (SQ from brisket). The FW treatments were no FW, a single 48 h FW (FW×1) before start of fattening or 48 h FW at 8 week intervals from weaning to start of fattening (FW×4). Individually penned steers were fed mixed hay and rolled barley diets containing no oil (Control; CON) or 5% oil (OIL) through growing, transition and fattening phases. Interaction of dietary oil and FW treatments did not affect any of the production factors. Decreased ($P=0.008$) dry matter intake (DMI) of the OIL diet was noted through the growing period; thus decreasing ($P=0.019$) total DMI by 112 kg/hd for the experiment and improved gain per unit feed ($P=0.019$) for the growing period. The FW×1 treatment reduced ($P=0.004$) average daily gain (ADG) through the transition period, but ADG tended to improve ($P=0.081$) during fattening and steers in FW treatments gained 1.38±0.07 versus 1.25±0.06 kg/d for those in the no FW treatment. Differences due to dietary oil or the FW treatments were not observed for any of the carcass characteristics. A diet×FW interaction ($P=0.001$) was observed for PPARγ expression in the PCD and SQ. Adipocyte marker expression was greater in PCD of steers in the FW×4 treatment with values for OIL fed steers being greater than of CON fed steers. Feeding the OIL diet increased ($P=0.001$) the weight percent of C18:1t10, C18:1t11, conjugated linoleic acid and n3 fatty acids by 178, 152, 66 and 32%, respectively. The n6:n3 ratio in PCD was decreased in OIL fed steers. Results indicate that repeated FW can enhance adipocyte marker expression in muscle thus improving the potential to increase marbling fat in steers, while oil, comprised of n3 and n6 fatty acids, increased biologically active fatty acids and decreased n6:n3 fatty acid ratios of tissues, without affecting productivity or carcass characteristics of the steers.

1. Introduction

Provision of dietary oil to beef cattle not only increased concentrations of biohydrogenation intermediates such as conjugated linoleic acid (CLA) and C18:1t11 (Mir et al., 2008a,

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Sackmann et al., 2003; Scollan et al., 2006) in beef, which can be beneficial to human health, but also C18:1t10, which may be harmful to humans (Bauchart et al., 2007). Along with alterations to fatty acid composition of muscle, dietary oil or oil seed, included to provide oil at 6% of diet, reduced carcass fat depth and numerically decreased USDA marbling scores despite the increase in dietary energy from the oil (Mir et al., 2008a). Marbling fat in beef carcasses is an economically valuable factor in North America and avenues to enhance or maintain this carcass characteristic are the focus of substantial research (Dodson et al., 2009). Towards the goal of maintaining marbling scores in carcasses, Mir et al. (2008b) demonstrated that subjecting heifers at yearling age to a single feed withdrawal (FW) for 48 h at the end of the growing period and before starting the fattening phase increased the percentage of carcasses that graded "Canada AAA" or "US Choice" and were akin to effects reported for feed restriction and re-feeding in cattle (Cassar-Malek et al., 2004). It is possible that feed restriction or FW causes loss of fat in adipocytes leading them to dedifferentiate and multiply or cause other cells to differentiate as observed in cell culture (Fernyhough et al., 2005), however confirmation of hyperplasia of adipocytes via cell marker; peroxisome proliferator activated receptor (PPARγ) analysis is necessary. When FW is followed by re-feeding there may be enhanced fat deposition in adipose tissues due to elevated lipogenesis in the adipocytes (Fried et al., 1983). Therefore, an experiment was conducted to test the hypothesis that application of a single 48 h FW or repeated 48 h FW at 8 week intervals would increase marbling fat and that provision of dietary oil would increase the proportion of fatty acids in the tissues that can be beneficial to humans. In order to address the increasing emphasis on n3 polyunsaturated fatty acids (PUFA) for human health (Harris, 2006; Harris et al., 2009) and the concerns of consumption of n6; pro-inflammatory fatty acids (Libby 2006), the dietary oil supplement selected for this experiment was a 50/50 mixture of flax and sunflower oils. The mixture of the two oils was employed in the present experiment because the beef from cattle fed only flax oil supplements developed off-flavours due its high susceptibility to oxidation (Scollan et al., 2006). Thus a 2×3 factorial experiment, with weaned steer calves was conducted with the objective of determining the effect of dietary supplementation with the selected oils at 5% of diet, to steers in the three FW treatments on production factors, carcass characteristics, adipocyte marker; peroxisome proliferation activated receptor γ (PPARγ) expression and fatty acid composition of muscle (*Pars costalis diaphragmatis*; PCD) and subcutaneous fat (SQ) from brisket fat.

2. Materials and methods

2.1. Animals and diets

A total of 72 spring born, European crossbred (with Hereford, Angus and Charolais genetics), steer calves were obtained upon weaning (body weight [BW] of 280.5 ± 5.8 kg and about 180 d of age) and maintained in the Individual Feeding Barn of the Lethbridge Research Centre and cared for according to the guidelines of the Canadian Council on Animal Care (2003). All procedures were approved by the Institutional Animal Care Committee (Approval # 0727) and details are provided in the following paragraphs. The calves, upon receipt from the supplier, were weighed on two consecutive days on full feed, vaccinated against clostridial diseases (Tasvac 8; Schering Canada Inc., Pointe-Claire, QC), infectious bovine rhinotracheitis, parainfluenza, and *Haemophilus somnus* (Resvac 4/Somnubac; Pfizer Canada, Kirkland, QC), and treated for warbles with a pour-on endectocide (Eprinex; Meriel Canada Inc., Victoriaville, QC). Steers were not implanted or provided growth promoters in the feed. The steers were allocated by BW to two blocks of lighter and heavier steers and one of six treatments was assigned to an equal number of steers in each BW block using a completely randomised design.

The six treatments were applied in a 2×3 factorial arrangement. The factors were two diets and three feed withdrawal (FW) treatments. Each diet was provided to the steers undergoing one of three FW treatments, where each FW lasted for 48 h, but water was available. The steers were individually fed either the control (CON) or oil (OIL) containing diets, where 5% of an equal mixture of flax and sunflower oil, replaced 5% of the steam rolled barley in the CON diet (Table 1). The FW treatments were no FW, single FW (FW×1, Mir et al., 2008b) at yearling age; just before start of the fattening phase or 48 h FW every 8 weeks, which occurred four times (FW×4), between initiation of the experiment after weaning and until they were approximately one year of age and before starting the fattening phase. Each FW was started on the weigh day after recording the BW and the feed bunks cleaned for all the steers. Those in the FW treatments did not receive feed after the BW was recorded for 48 h, after which the feed was provided. The animals were provided the grower diets until the last FW (165 d; November 16, 2007 to April 28, 2008) and then provided transition diets (28 d; April 28 to May 26, 2008), where the steam rolled barley was increased by 9, 12, 12, 5 and 5% every 5 d, to achieve the grain content indicated in Table 1. The canola meal was decreased by 50% of original to 0% in two, 5 d intervals. The hay in the diets was reduced by 10, 10, 10, 5 and 5% every 5 d to achieve the hay content in the fattening diets, which was fed until slaughter (66 d; May 26 to August 1, 2008).

The animals were fed the diets as total mixed rations once daily. Record of feed provided was maintained and the unconsumed feed or orts for each animal was weighed every week and summed for the weeks between weigh days. Samples from the orts were collected for dry matter (DM) determination and subtracted from DM of diet offered to obtain DM intake (DMI). Samples of the diets were obtained weekly and frozen. The diet samples were pooled over the weeks between weigh days, sub-sampled and frozen until they were analysed for DM, CP, NDF, ADF and ether extract (Dayani et al., 2004). The NEm and NEg/kg of the diets were estimated from the composition of the diets and from published energy values for the various ingredients (NRC; 2000). Animals were weighed every 4 weeks through the growing phase and every 3 weeks during the fattening phase and average daily gain (ADG) for each period was calculated. The total feed consumed during the growing, transition and fattening phases was determined. The efficiency of feed utilisation during the growing, transition and fattening phases, as gain per unit feed was calculated from the ADG and DMI for each steer. At the end of the trial when steers were visually adjudged by the abattoir purchaser as carrying