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Growth and carcass fatty acid composition of beef steers fed soybean oil for increasing duration before slaughter

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ABSTRACT

Duration of soybean oil (SBO) supplementation needed to enhance carcass conjugated linoleic acid (CLA) and *trans*-vaccenic (TVA) content was examined using 96 beef steers (293.6 ± 3.9 kg) fed a 78% corn-based diet supplemented with SBO for 0, 77, 137, or 189 days before slaughter. Duration of SBO supplementation had no effect ($P \geqslant 0.15$) on animal performance or carcass traits, nor ($P \geqslant 0.15$), total, total saturated, or total polyunsaturated fatty acids of *Longissimus dorsi* (LD). Concentrations of CLA in LD were not affected ($P \geqslant 0.18$) by SBO supplementation. Concentrations of monounsaturated fatty acids (MUFA) decreased linearly ($P = 0.03$) in LD, whereas TVA increased ($P = 0.04$) in adipose tissue and tended ($P = 0.07$) to increase in LD with increasing duration of SBO supplementation. Supplementing SBO to a concentrate-based diet may enhance TVA without impacting CLA, while reducing the MUFA content of lean beef.

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1. Introduction

Recent research on the role of conjugated linoleic acid (CLA) has revealed a wide range of beneficial effects including anticarcinogenic (Ip et al., 2002; Parodi, 1994), antiatherogenic (Lee, Kritchevsky, & Pariza, 1994), and antiobesity activities (Pariza, Park, Cook, Albright, & Liu, 1996) as well as the ability to stimulate immune function (Miller, Park, Pariza, & Cook, 1994). Ruminant food products are naturally enriched with CLA, which is formed in the process of biohydrogenation of unsaturated fatty acids by ruminal microorganisms (Bauman, Baumgard, Corl, & Griinari, 2000). Additionally, $18{:}1^{trans\text{-}11}$ (*trans*-vaccenic acid, or TVA) is also formed in the biohydrogenation process, which can subsequently be converted to CLA in the human body through the action of -9 desaturase at the tissue level (as reviewed by Bauman et al. (2000). Thus, dietary manipulation to enhance the natural production of CLA and TVA by the rumen microflora may be an effective means of altering the fatty acid composition of beef.

The most common method of enhancing the CLA and TVA content of ruminant meat and dairy products is to provide the animal with additional dietary unsaturated fatty acids, usually from plant oils such as soybean oil (SBO), for use as substrates for ruminal biohydrogenation (Khanal & Olson, 2004; Mir et al., 2003). However, supplementing SBO to finishing beef cattle can represent a significant cost to the producer. Additionally, the optimal duration of SBO supplementation needed to achieve the desired enhancement of carcass CLA concentrations is not known. It was our hypothesis that the most economical and practical method of enhancing the CLA and TVA content of beef is to determine the minimum duration of SBO supplementation needed to achieve such enhancement of carcass CLA and TVA concentrations. Therefore, our objective was to examine the effects of duration of SBO supplementation before slaughter on growth and carcass fatty acid composition of beef steers.

2. Materials and methods

2.1. Animals and diets

Ninety-six Gelbvieh × Angus rotationally-crossed steers (avg. initial body weight = 294 ± 3.9 kg) were used in a 180-day randomized complete block-designed experiment. Steers were blocked by initial BW and housed in one of 16 pens (six steers/pen) at the University of Wyoming Animal Science Livestock Center (Laramie, WY). All animal care followed procedures approved by the University of Wyoming Institutional Animal Care and Use Committee. Steers were dewormed (Dectomax, Fort Dodge Animal Health, Fort Dodge, IA) and implanted (Synovex-S, Fort Dodge Animal Health, Fort Dodge, IA) at the initiation of the trial, and reimplanted (Synovex-PLUS, Fort Dodge Animal Health, Fort Dodge, IA) on day 90 of the trial. Weights of the steers were taken at the beginning and at approximately 30-day intervals throughout the trial. Initial and

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final weights were considered the average of weights taken on two consecutive days.

Four experimental treatments consisted of targeted 0, 60, 120, or 180 days of SBO supplementation prior to slaughter. Experimental diets were formulated to contain 13% crude protein using [dry matter(DM) basis] 78% cracked corn, 12% chopped (2.54 cm) oat hay and 10% soybean meal/urea-based supplement, with or without 5% added SBO (CONTROL vs. OIL; Table 1). Experimental diets were fed as a total mixed ration at 0700 once daily throughout the experiment. Feed refusals were collected and weighed once weekly. Composite samples of individual dietary components (corn, oat hay, soybean oil and supplement) were collected at 30-day intervals throughout the trial. Composites were analyzed for DM and N (LECO FP-528, LECO Corp., Henderson, NV) content.

2.2. Carcass data, sample collection, and analysis

The experiment was terminated when an estimated 50% or more of all steers were expected to grade USDA Choice by visual appraisal. Consequently, the actual days steers received SBO before slaughter was 0, 77, 137, and 189 days for the targeted 0, 60, 120, and 180-day treatments, respectively. At the conclusion of the trial, all steers were transported to a commercial slaughter facility and harvested following normal industry practices. Hot carcass weights (HCW) were collected on the kill floor before chilling. Dressing percentage (DP) was calculated by dividing HCW by 4% shrunk live weight × 100. Carcasses were chilled at 4 °C for 24 h and ribbed by cutting perpendicular to both the long axis and the split surface of the vertebral column at the 12th thoracic vertebra. Another cut at the 11th thoracic vertebra was made for subsequent rib sample removal. Trained technicians performed all carcass measurements. Amount of external carcass fat, or fat depth, was measured perpendicular to the outside surface at a point three-fourths of the medial-lateral distance across the *Longissimus dorsi* (LD) from its medial end using a stainless steel ruler (beef probe). This measurement was adjusted to reflect unusual amounts of fat at other anatomical locations on the carcass. *L. dorsi* area (REA) was measured using a grid calibrated in tenths of a square inch as designated by the Agricultural Marketing Service of the USDA. Yield grade was calculated as 2.5 + (2.5 × 12th rib adjusted fat thickness, in.) + (0.0038 × HCW, lb) + (0.2 × percentage KPH) − (0.32 × REA); where KPH is kidney, pelvic, and heart fat. Intramuscular fat (marbling) was estimated on the lean surface of the LD at the 12th rib by a USDA grader. Maturity was estimated by bone characteristics, ossification of cartilage at various carcass locations, and color and texture of the LD. Estimated marbling and maturity factors were combined to determine a final USDA quality grade.

A one-vertebra thick rib sample, which included portions of 11th and 12th thoracic vertebra and the 12th rib, was removed immediately after carcasses were graded and all carcass data collected. Rib samples were packaged in sealable plastic bags and placed on ice for transport to the University of Wyoming Meat Lab. Rib samples were cut into bone-in steaks and scraped to remove bone dust. A 5 g sample of LD muscle and a 2.5 g sample of subcutaneous adipose tissue was collected from each steak and stored in sealed plastic bags at −20 °C until fatty acid analysis. The LD samples were later weighed and lyophilized (Genesis SQ Super ES Freeze Dryer, The Virtis Co., Gardiner, NY), and both LD and adipose tissue samples (100 mg) were subjected to direct transesterification as described by Murrieta, Hess, and Rule (2003). Fatty acid composition was determined by gas-liquid chromatography using a 100-m capillary column (SP2560, Supelco, Bellefonte, PA) set for separation of *cis*- and *trans*-18:1 isomers, and for *cis*-9, *trans*-11 and *trans*-10, *cis*-12 CLA isomers. The calculation for the index of stearoyl-COA desaturase (Δ-9 desaturase) activity (%) was adapted from Malau-Aduli, Siebert, Bottema, and Pitchford (1997).

2.3. Statistical analyses

All data were analyzed using the GLM procedure of SAS (SAS Institute Inc., Cary, NC) for a randomized complete block design using pen as the experimental unit. Single degree of freedom orthogonal contrasts were used to determine linear, quadratic, and cubic effects of duration of soybean oil inclusion in the diet. Contrast coefficients were computed for unequal spacing of treatments using the IML procedure of SAS (SAS Institute Inc., Cary, NC) based on the actual days steers received SBO. Because there were no significant ($P \leqslant 0.05$) quadratic or cubic contrasts detected, only linear contrast results are presented.

Table 1
Composition of the control and soybean oil-supplemented experimental diets fed to beef steers to increase the duration of soybean oil supplementation before slaughter.

	Control[a]	Oil
Ingredient, % of DM[b]		
Coarse cracked corn	79.18	73.47
Chopped oat hay	12.00	12.00
Soybean oil (SBO)	0.20	5.20
Soybean meal	5.96	6.61
Urea	0.55	0.61
Calcium carbonate	1.50	1.50
Trace-mineralized salt[c]	0.50	0.50
Vitamin predmix[d]	0.08	0.08
Rumensin premix[e]	0.02	0.02
Tylan premix[f]	0.01	0.01
Chemical analysis		
DM, %	88.52	89.03
CP, % of DM[g]	13.08	13.04
TDN, % of DM[h]	83.17	87.44

[a] Contained either 0 (CONTROL) or 5% added soybean oil (OIL). Soybean oil was also included at 2% of supplement DM, providing an additional 0.2% soybean oil in both diets.
[b] DM = Dry matter.
[c] Contained 98.0% NaCl, 0.35% Zn, 0.28% Mg, 0.175% Fe, 0.035% Cu, and 0.028% I.
[d] Contained 17,636,800 IU vitamin A, 1,763,680 IU vitamin D_3, and 88,184 IU vitamin E per kg.
[e] Provided monensin at 30 g/ton of total mixed ration (DM basis).
[f] Provided tylosin at 10 g/ton of total mixed ration (DM basis).
[g] CP = Crude protein.
[h] TDN = Total digestible nutrients. Calculated from tabular values (NRC, 1996).

3. Results and discussion

3.1. Animal performance and carcass characteristics

Duration of SBO supplementation had no effect ($P \geqslant 0.44$) on DM intake, average daily gain (ADG), or feed efficiency (Table 2). The lack of improvement in feedlot performance was somewhat unexpected, as we made no attempt to formulate diets on an isoenergetic basis (i.e. SBO replaced corn in the diet; Table 1). Due to its greater energy density, feeding supplemental fat to feedlot cattle usually improves feedlot growth and efficiency. In his review of cattle finishing trials, Brandt (1995) concluded that cattle should be supplemented with approximately 6% dietary fat to increase animal performance and maximize feed efficiency. However, Beaulieu, Drackley, and Merchen (2002) demonstrated that adding 5% SBO to the diet of feedlot heifers for a minimum of 102 days had no effect on DM intake, ADG, or efficiency, a response similar to that observed in our study. Griswold et al. (2003) also noted that addition of either 4 or 8% SBO to the diet of finishing steers has no effect on DMI, ADG or feed efficiency. In other work, Garcia, Amstalden, Morrison,