EFFECT OF PASTURE VS. CONCENTRATE FEEDING WITH OR WITHOUT ANTIOXIDANTS ON CARCASS CHARACTERISTICS, FATTY ACID COMPOSITION, AND QUALITY OF URUGUAYAN BEEF.

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Background

Beef cattle production systems in Uruguay rely almost exclusively on grazed pastures. However, more recently intensive beef production systems have gained interest by some beef producers. The focus is to produce a differentiated product in a vertically integrated manner to target both domestic, but particularly international markets. Dietary recommendations for humans promoting the consumption of less saturated fat have led to an increased interest in meats containing more unsaturated fatty acids. Recent research has focused on the nutritional importance of the omega-3 (n-3) fatty acids in the human diet, and on conjugated linoleic acid (CLA) isomers because of their anticarcinogenic properties (Ha et al. 1990). Previous research has shown that including grass in the diet of dairy and beef cattle increased CLA concentration in milk and beef intramuscular fat, respectively. Although an increase in the n-3 fatty acid concentration is desirable from a human health perspective, oxidative stability of meat is reduced. Thus, enrichment with antioxidants is necessary in order to prevent the risk of oxidative damage.

Objectives

Compare carcass characteristics, beef quality, and longissimus fatty acid composition from cattle finished on pasture or on a concentrate-based diet; and evaluate the effect of antioxidants, antemortem vitamin E and postmortem vitamin C, on product shelf life.

Methods

Thirty Hereford steers backgrounded on pasture were finished either on forage (n=10, FOR) or concentrate (n=20, CONC) during summer. Half of the steers finished on concentrate were supplemented with 1000 I.U vitamin E/head/d (VITE) for 100 days.

***Sampling procedures*:** The ribeye roll (IMPS 112) was fabricated into steaks and the clod (IMPS 114) was trimmed and ground. Ground beef was formed into 114 g patties after half of the ground beef was treated with sodium ascorbate (1% w/v, vitamin C). Steaks and patties were individually placed on Styrofoam trays, over-wrapped with oxygen permeable film, and displayed at 2°C in a lighted cooler for color and lipid stability measurements.

***Instrumental color*:** L*, a* and b* were recorded using a Minolta chromameter (CR-210) on subcutaneous fat and ribeye area at 24 h postmortem. Steak and ground beef color measurements were obtained at 0, 5, 13 and 21 d and 0, 3, and 8 d of display, respectively.

***Lipid oxidation analysis*:** Lipid oxidation was determined by TBARS (Jo and Ahn, 1998) on steaks and ground beef immediately after measuring color.

***Fatty acid composition*:** Total lipid was determined following the chloroform-methanol procedure of Folch et al. (1957). Lipids were converted to fatty acid methyl esters following the method of Duckett et al. (2002) and analyzed using gas chromatography.

***Tenderness (Warner-Bratzler Shear Force)*:** Steaks (2.5 cm) were vacuum packaged, stored in a cooler at 2°C and frozen after 1, 7 and 14 d of aging. Steaks were thawed for 24 h at 2°C, and boiled in a water bath to an internal temperature of 71°C. Six 1.27-cm cores per steak were sheared using a Warner-Bratzler meat shear machine (Standard Shear Model 2000 D).

***Vitamin E analysis*:** Muscle α-tocopherol concentrations were determined using reverse phase HPLC (AKTA Purified System) with fluorescence detection (Shimadzu RF-10A XL).

***Statistical analysis*:** Results were analyzed by analysis of variance using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Pre-planned, non-orthogonal contrasts were used to compare means from cattle finished on pasture, concentrate-fed steers with or without vitamin E supplemention, and from ground beef samples treated with vitamin C. Variables measured over time were analyzed as repeated measures. Vitamin E supplementation did not alter any carcass characteristic, Warner-Bratzler shear force, or fatty acid composition, and data were pooled across vitamin E treatment for concentrate-fed cattle.

Results and Discussion

Carcasses from cattle finished on concentrate had greater ($P < 0.05$) carcass weight, conformation, degree of finishing, fat depth, and ribeye area than pasture finished animals. Dietary treatment did not alter ($P > 0.05$) age at slaughter, pistola cut weight, or longissimus muscle pH (Table 1). Carcasses from FOR showed darker ($P < 0.05$) longissimus color and yellower ($P < 0.05$) fat than CONC.

Initial tenderness did not differ ($P > 0.05$) between FOR and CONC (4.7 vs. 4.5 kg, respectively). However, FOR beef had lower ($P < 0.05$) WBSF values at 7 and 14 d postmortem than CONC (2.9 vs. 3.8 kg, and 2.8 vs. 3.5 kg respectively).

Longissimus concentrations of α-tocopherol were greater ($P < 0.01$) for FOR and CONC-VITE (3.91 and 3.74 µg/g, respectively), compared to CONC (2.92 µg/g). Arnold et al. (1993) proposed minimum tissue levels of 3.5 µg α-tocopherol/g muscle as the target concentration to have a significant impact on the reduction of pigment and lipid oxidation. Results from different field studies reported that 500-1,000 IU/animal/d of vitamin E for 90-100 days prior to harvest is efficacious for beef marketed in both domestic and export trades.

Steaks from FOR and CONC-VITE had similar ($P > 0.05$) TBARS values, which were lower ($P < 0.05$) than CONC during 21 d of display (Figure 1a). Ground beef from VITE had the lowest TBARS, while samples from FOR animals had numerically higher TBARS levels than other treatments (Figure 1b). Mincing muscle tissue disrupts cellular integrity and exposes more of the lipids to the oxidative catalysis; it also dilutes the antioxidants and increases the exposure of the tissue to oxygen (Hultin, 1988). This may explain the greater lipid oxidation observed in ground beef compared to steaks from FOR. There was no interaction ($P > 0.05$) between dietary treatment (FOR, CONC, CONC-VITE) and vitamin C addition to ground beef indicating the lack of a synergistic effect between vitamin E and C on color and lipid stability. Vitamin C addition to ground beef did not alter ($P > 0.05$) lipid oxidation.

Vitamin E supplementation of CONC had no effect ($P > 0.05$) on color stability of ground beef or steaks. Color a* (redness) and b* (yellowness) values were higher ($P < 0.05$) when vitamin C was added to ground beef.

Longissimus fatty acid content of CONC was twofold greater ($P < 0.01$) than FOR (3.18 vs. 1.68 %, respectively). The percentages of C14:0, C16:0, and C18:1 fatty acids were higher ($P < 0.01$) in the intramuscular fat of CONC, while FOR showed greater ($P < 0.01$) proportions of

C18:0, C18:2, C18:3, C20:4, C20:5, and C22:5. Total CLA and CLA isomer cis-9, trans-11 were higher ($P < 0.01$) for FOR than CONC (5.3 vs. 2.5 and 4.1 vs. 2.3 mg CLA/g lipid, respectively). Intramuscular fat from FOR had more favorable polyunsaturated:saturated and omega-6: omega-3 fatty acid ratios than CONC (0.20 vs. 0.13 and 1.4 vs. 3.0, respectively).

Conclusions

Pasture-fed carcasses showed darker longissimus color and yellower fat than concentrate-fed. Altough pasture-fed carcasses were lighter and leaner than concentrate-fed, there were no differences in initial tenderness between the groups. Moreover, pasture-fed beef showed a greater potential for postmortem tenderization through aging. Supplementation with α-tocopherol was sufficient to achieve similar muscle α-tocopherol content to pasture-fed cattle, at levels beyond the proposed critical concentrations for improving shelf life. Vitamin E supplementation of concentrate-fed steers increased lipid stability of ground beef and steaks, but was unable to improve color stability. Vitamin C addition to ground beef increased color stability without altering lipid oxidation. Finishing cattle on pasture enhanced the unsaturated fatty acid profile of intramuscular fat in beef including conjugated linoleic acid and omega-3 fatty acids.

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Tables and Figures

Table 1. Mean (± S.E.) carcass characteristics of forage- and concentrate-fed steers.

Characteristic	FOR (n=10)	CONC (n=20)	Carcass characteristics were evaluated according to INAC (1997)
Hot carcass wt, kg	$225.6^a \pm 4.405$	$240.1^b \pm 3.115$	
Age	1.9 ± 0.121	1.8 ± 0.086	Based on dentition, a lower number indicates younger animal (1: baby teeth to 4:full teeth)
Conformation	$3.0^c \pm 0.123$	$2.7^d \pm 0.087$	A lower number indicates better conformation (1 to 6)
Degree of finishing	$1.5^a \pm 0.095$	$2.0^b \pm 0.067$	A lower number indicates lack of finishing (0 to 4)
Pistola cut wt, kg	46.5 ± 0.911	47.4 ± 0.645	Round and loin
Fat depth, mm	$3.8^a \pm 0.614$	$6.1^b \pm 0.434$	
Ribeye area, cm^2	$55.2^a \pm 2.168$	$62.9^b \pm 1.533$	a,b Means within the same row with different superscripts differ ($P<0.05$)
pH	5.7 ± 0.039	5.7 ± 0.028	c,d Means within the same row with different superscripts differ ($P<0.10$)

Figure 1. TBARS (mg malonaldehyde/kg sample) levels for a) longissimus steaks b) ground beef.