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Conjugated Linoleic Acid (CLA) and Vitamin E Levels In Pasture Forages for Beef Cattle

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Introduction

Foods of ruminant origin have been found to contain the largest quantities of CLA. Conjugated linoleic acid may have potential human health benefits. The $C_{18:2}$ *cis*-9, *trans*-11 isomer of CLA has been shown to have anticarcinogenic properties in animal models (Ip et al., 1994). The $C_{18:2}$ *trans*-10, *cis*-12 isomer of CLA has been reported to increase the lean to fat ratio in growing animals (Park et al., 1999; Azain et al., 2000). Antidiabetic effects of CLA isomers have also been reported (Houseknecht et al., 1998; Ryder et al., 2001). For these reasons, increasing the CLA content of foods may increase their nutritive and therapeutic values. Dhiman et al. (2005) attempted to increase the CLA content of beef by adding soybean oil to the diets of finishing steers for 105 days; however, results showed no significant difference in total CLA content among treatments. The objective of this study was to identify the long-term influence of feeding high grain diets or forages (grazed grass and hay) to beef steers on the fatty acid profile of beef, including CLA and vitamin E content and quality of beef.

Materials and Methods

Fifteen steer calves with an average weight of 517 lbs were assigned to one of three treatments (Control = **CTL;** Grain plus pasture = **GPS** and Pasture = **PS**). There were two feeding periods: a backgrounding and a finishing period. During the backgrounding period, CTL and GPS animals were fed ad libitum a diet consisting of 52% corn silage, 21.3% alfalfa hay, 25.0% rolled barley, and 1.7% mineral-vitamin premix on a DM basis. The PS animals were fed a diet containing alfalfa hay and free choice minerals and vitamins. After 195 days on the backgrounding ration, steers were

switched to their respective finishing diets. At the end of the backgrounding period, steers in CTL, GPS, and PS treatments weighed 997, 968, and 827 lbs, respectively.

During the finishing period, steers in CTL were fed a basal TMR consisting of 12.3% corn silage, 6.7% alfalfa hay, 76.4% rolled barley, and 4.6% mineral-vitamin premix. Steers in GPS and PS treatments grazed on pasture and did not receive any supplemental grain, but received free choice minerals and vitamins during the finishing period. After a finishing period of 130 days, animals were harvested. Mean live body weights at the time of harvest were 1309, 1133, and 1107 lbs for CTL, GPS, and PS treatments, respectively.

After slaughter, muscle and adipose tissue samples were collected from the the *longissimus dorsi* (**LD**) and *semitendinosus* (**ST**) for fatty acid analysis. For sensory evaluation of beef, four 2.5 cm thick top loin steaks were cut from the left side of each carcass at 24 h post mortem. Steaks were vacuum-packaged, aged in a cooler for 7 days and were frozen until the time of sensory evaluation by ten expert panelists. A top loin steak and tenderloin steak were tested for color stability. Neck muscle samples were analyzed for vitamin E content. Results are summarized in the next section.

Results and Discussion

At the time of harvest, levels of $C_{18:1}$ *trans* fatty acids were significantly higher in beef from PS cattle compared with any of the other treatments (Table 1). A point worth noting here is that the beef from LD in cattle from PS group was higher in $C_{18:1}$ *trans* fatty acids than ST (6.2 vs 4.2 g/100 g of total fatty acids, respectively; data not shown in Table 1). Raising beef animals on forage and pasture increased (336%) the proportions of $C_{18:1}$ *trans* fatty acids and decreased $C_{18:1}$ *cis* fatty acids compared with animals fed high-grain diets (CTL). Beef samples in the study were not analyzed for different $C_{18:1}$ *trans* fatty acids, however, $C_{18:1}$ *trans*-11 represents more than 50% of the total $C_{18:1}$ *trans* fatty acids. The $C_{18:1}$ *trans*-11 also has potential health benefits because it can be converted to $C_{18:2}$ *cis*-9, *trans*-11 CLA in the human body (Turpeinen et al., 2002).

Generally, GPS and PS animals had 218 and 466% more $C_{18:2}$ *cis*-9, *trans*-11 CLA respectively, compared with CTL animals (Figure 1). The large increase in $C_{18:2}$ *cis*-9, *trans*-11 CLA in beef tissues from animals raised on forage and pasture alone is similar in magnitude to the increase of $C_{18:2}$ *cis*-9, *trans*-11 CLA in milk from dairy cows grazing on pasture (Dhiman et al., 1999). The GPS animals were taken off the backgrounding diet 5 months prior to slaughter and were on pasture with PS animals during the finishing period. This allowed ample time for rumen microorganisms to adjust to a pasture-based diet. Results from our study suggest that feeding starchy grain during backgrounding may decrease expression of the mechanism responsible for the synthesis and incorporation of $C_{18:2}$ *cis*-9, *trans*-11 CLA into tissues. Raising beef animals on forage/pasture instead of high-grain diets increased total CLA by 466% in our study.

Availability of $C_{18:2}$ *cis*-9, *trans*-11 CLA to consumers from 100 g of beef was calculated for CTL and PS treatments. Fat content values were estimated to be 5.6 g/100 g of fresh meat in CTL and 3.3 g/100 g of fresh meat in PS using a method described in Aberle et al. (2001). Wahrmund-Wyle et al. (2000) determined the cooking yield of top loin steak to be approximately 79% and this value was used in calculating the available CLA in meat. The average $C_{18:2}$ *cis*-9, *trans*-11 CLA values used were 0.27 and 1.53 g per 100 g of fat in CTL and PS treatments (Figure 1). Based on our calculations, the $C_{18:2}$ *cis*-9, *trans*-11 CLA available from CTL and PS beef was 12 and 40 mg/100 g of meat, respectively. These results suggest that despite the considerably lower total fat content of beef from forage fed animals (PS), the availability of $C_{18:2}$ *cis*-9, *trans*-11 CLA is 3.3 times greater than beef from animals fed high-grain diets (CTL). In addition to this there would be more CLA that will be available through the conversion of The $C_{18:1}$ *trans*-11 in body tissues.

Beef from cattle in the PS group contained significantly higher proportions of C18:3 *cis*-9,12,15 fatty acid than any of the other treatments. This can be explained by the fact that green forages are rich in $C_{18:3}$ (Dhiman et al., 1999), thereby resulting in higher levels of $C_{18:3}$ in beef from PS animals. The $C_{18:3}$ *cis*-9,12,15 fatty acid is one of the omega-3 fatty acids present in beef. Higher proportions of $C_{18:3}$ *cis*-9,12,15 fatty acid in grass-fed beef is beneficial for human health because supplementation of omega-3 fatty acids has been shown to decrease mitogen-stimulated lymphocyte proliferation, enhance immune function (Thies et al., 2001), and help prevent heart disease (Albert et al., 1998). It is interesting to note that the mean for $C_{18:3}$ *cis*-9,12,15 fatty acid in beef from CTL cattle was only approximately 60% of that in GPS and PS (0.30 vs. 0.50).

Meat from animals finished on pasture had a 300% increase ($P < 0.01$) in vitamin E content when compared with animals finished on grain (Figure 2). Higher vitamin E concentrations have been shown to improve the color stability of beef. Steaks from pasture-raised animals (GPS and PS) retained their redness better than steaks from animals (CTL) that were fed high-grain diets. The improved redness retention is most likely associated with the naturally increased levels of vitamin E in meat from pasture-finished animals compared to meat from grain-finished animals.

There was no difference in tenderness or juiciness for steaks from animals among different treatments. It has been shown that the degree of doneness has a greater effect on taste panel juiciness ratings than animal age or marbling score. Animals raised on forage and pasture (PS) had the highest off-flavor score, which was described as a “grassy” flavor by two of the more experienced panelists. Interestingly, steaks from animals in GPS, which were also finished on pasture, had no off-flavor detected by the panelists. Results from the current study suggest that experimental diet appeared to have little effect on the sensory characteristics of beef as perceived by taste panel members, with the exception of beef from PS animals having lower consumer-perceived beef flavor and a noticeable “grassy” flavor. An off-flavor can be a concern; however, this off-flavor is a perceived image based on personal preference.

Conclusions

In summary the concentration of $C_{18:2}$ *cis*-9, *trans*-11 isomer of CLA in beef can be raised by as much as 466% by feeding forages and pasture only compared with beef from animals fed typical feedlot high-grain diets. Finishing cattle on pasture increased the vitamin E content of beef by 300% compared to beef from animals finished on a traditional high-grain diet. Beef from animals raised on forage and pasture retains its redness better than meat from grain-finished cattle. Beef from animals raised on forage and pasture alone may have a perceived off-flavor. However, other beef quality characteristics were not affected by the diets fed to animals.

Table 1. Proportions of selected fatty acid in beef from *longissimus* and *semitendinosus* of carcass from cattle fed high grain or forages, g/100 g of total fatty acids.

	Treatment*				
Fatty acid	CTL	GPS	PS	S.E.M**	*P* = F
$C_{18:1}$ *trans*	1.19[c]	3.34[b]	5.19[a]	0.30	0.01
$C_{18:1}$ *cis*	42.7[a]	41.5[ab]	38.8[b]	0.80	0.03
$C_{18:2}$ *t*10, *c*12, CLA	0.015[b]	0.025[b]	0.042[a]	0.006	<0.01
$C_{18:3}$ *c*6,9,12	0.015[b]	0.023[b]	0.038[a]	0.003	<0.01
$C_{18:3}$ *c*9,12,15	0.30[b]	0.51[a]	0.49[a]	0.01	0.01

*Means within rows with differing superscripts differ by *P* value mentioned in the last column.
**Standard error of mean.

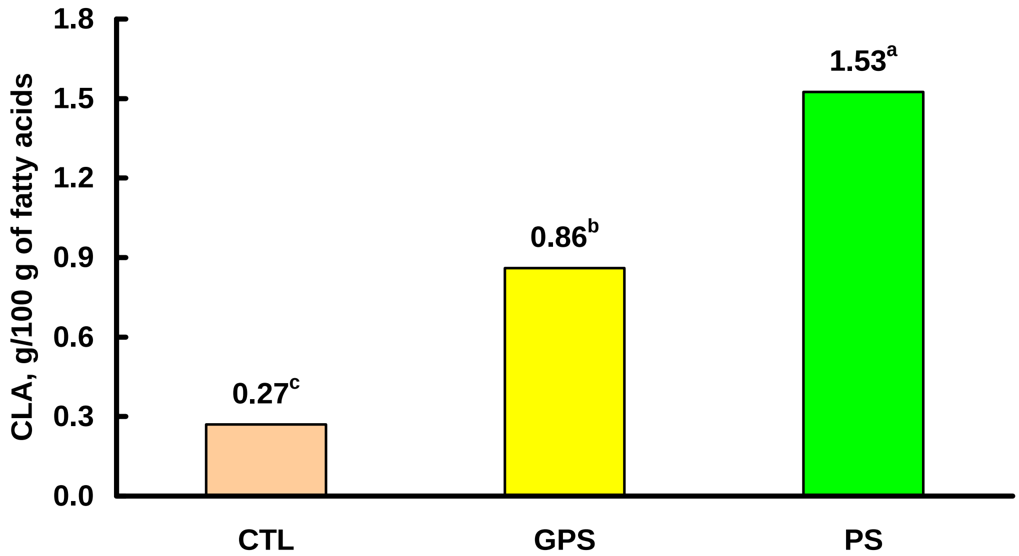

Figure 1. Conjugated linoleic acid ($C_{18:2}$ *cis*-9, *trans*-11 CLA) content of beef from cattle fed diets containing high grain or cattle raised on forages.

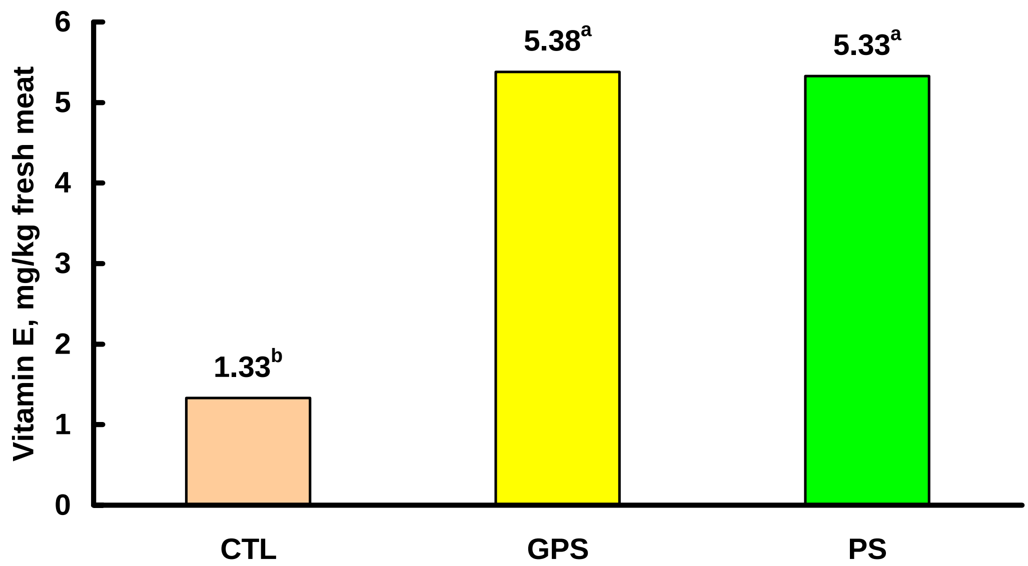

Figure 2. Vitamin E content of beef from cattle fed diets containing high grain or cattle raised on forages.

Table 2. Taste panel test results of meat from cattle fed diets containing high grain or cattle raised on forages (n = 50).

	Treatment*					
Test**	Standard***	CTL	GPS	PS	S.E.M	*P* = F
Tenderness	6.06[a]	4.94[b]	4.64[b]	4.40[b]	0.17	0.01
Juiciness	4.60	5.06	4.60	4.28	0.19	0.08
Beef flavor	4.26[ab]	4.72[a]	4.24[ab]	3.74[b]	0.15	0.01
Off flavor	1.32[b]	1.24[b]	1.34[b]	1.82[a]	0.10	0.01

*Means within rows with differing superscripts differ by *P* value mentioned in the last column.
**Higher value signifies more tenderness, juiciness, intense beef flavor and intense off flavor.
***Standard: United States Department of Agriculture average choice top loin steak.

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