Fatty Acid Profiles and Content of Pasture- and Feedlot-Finished Beef Steers Supplemented with 25-Hydroxyvitamin D_3 Prior to Harvest

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Summary and Implications

Pasture- and feedlot-finished beef steers (n = 48) were supplemented with 25-hydroxyvitamin D_3 (25-OH D_3) on d 7 prior to harvest. The longissimus (LM), semimembranosus (SM), and gracilis (GR) muscles were collected after harvest for evaluation of lipid percentage, fatty acid profiles, and fatty acid content. Lipid percentages did not differ between pasture- and feedlot-finished steers. Muscles, however, did differ in lipid percentage with the GR having the least lipid followed by the SM and LM. Fatty acid profiles differed as a result of dietary treatment and also were different among muscles. Monounsaturated fatty acids (MUFA) were greater in steaks from feedlot-finished steers than pasture-finished steers. Polyunsaturated fatty acids (PUFA) were greatest in the GR muscle as compared with the LM and SM. Conjugated linoleic acid (CLA) was greater in the longissimus and semimembranosus of pasture-finished steers than other muscles and feedlot-finished steers. Concentrations of C18:3n3 were also greater in the LM of pasture-finished steers. Data for fatty acid content were similar to those for fatty acid profiles, indicating that 100 g of tissue would contain 14 mg of CLA and that the LM had the greatest total content of saturated fatty acids (SFA), MUFA, and PUFA.

Introduction

Consumers are becoming more health conscious, especially where dietary fat is concerned. CLA and omega-3 fatty acids have been reported to have purported human health benefits including the anti-atherogenic, anti-obesity, and ant-diabetic effects. In light of this consumer trend, it would be beneficial to alter the fatty acid profile of beef to enrich these health-promoting fatty acids. Pasture-finished steers have been reported to have increased concentrations of these fatty acids. In addition, no previous research has documented if pre-harvest supplementation of 25-OH D_3 has an effect of fatty acid profiles. Therefore, the objective of this research was to evaluate the lipid percentage, fatty acid profiles, and fatty acid content of pasture- and feedlot-finished steers supplemented with 25-OH D_3.

Materials and Methods

British-breed beef steers (n = 48) averaging 814 lbs. were assigned to one of two diets on April 18th, 2006. A typical feedlot ration containing 10% wet distillers' grain was fed to the steers assigned to the feedlot diet (Table 1). Feedlot steers were housed at the Iowa State University (ISU) Beef Nutrition Farm in Ames, IA in outside lots and fed once daily. The steers assigned to pasture-finishing continuously grazed predominantly bromegrass pasture at the Western Research and Demonstration Farm (Castana, IA). Pasture-finished steers were supplemented once daily, initially with 10 lbs./head daily of a pellet containing dried distillers' grain (Table 2) and then, on July 13, 2006, supplement was increased to 15 lbs./head daily due to deteriorating pasture conditions. Pasture-finished steers also had access to a vitamin/mineral block that supplied Rumensin®. All steers were implanted with Component TE-S prior to initiation of the study.

After 12 weeks on the respective feeding regimens, ultrasound image evaluation indicated that a number of steers were nearing 0.5 in. of 12th rib fat. At this time, steers were designated to 1 of 3 harvest dates (3 weeks apart) based on estimated 12th rib fat thickness. On d 7 prior to harvest, steers received a bolus of either 0 or 500 mg of 25-OH D_3. At 48 hours after harvest, strip loins and inside rounds were collected for analysis. Collection of these cuts allowed for analysis of the longissimus, semimembranosus, and gracilis muscles. Lipid extraction was conducted and then lipid was esterified for fatty acid analysis by gas chromatography. The atherogenic index was calculated by using the equation $[C12:0 + (4*C14:0) + C16:0]/\Sigma MUFA + \Sigma PUFA$. Lipid content in 100 g of tissue was calculated by multiplying the lipid percentage of the tissue by the fatty acids in 100 mg of lipid. Statistical analysis was conducted using PROC MIXED of SAS.

Results and Discussion

Lipid Percentage. Lipid percentage did not differ ($P = 0.16$) between pasture- and feedlot-finished steers (1.89 vs. 2.12%). Muscles differed ($P < 0.0001$) in lipid percentage with the GR having the least lipid followed by the SM and the LM (1.54, 195, and 2.54%, respectively). These differences among muscles may be attributable to differences in muscle metabolism and fiber type.

Supplementation with 25-OH D_3 also resulted in a decrease ($P = 0.04$) in lipid percentage compared to controls (1.85 vs. 2.17%, respectively), which was unexpected. While this result may be attributable to error, we cannot exclude the possibility that 25-OH D_3 supplementation could alter lipid metabolism, though at this point it seems unlikely that such as decrease in lipid percentage could occur just seven days prior to harvest.

Fatty acid profile. CLA and C18:3n3 concentrations were dependent upon diet and the muscle evaluation. The longissimus had greater concentrations of CLA and C18:3n3 in the longissimus of pasture-finished steers than feedlot-finished steers (Table 3). MUFA are considered healthy because they can aid in blocking the development of coronary heart disease. Total MUFA were greater in the feedlot-finished steers than the pasture-finished steers (Table 4). However, concentrations of C18:1 *t*9 and *t*11 were greater in pasture-finished steers which is of interest because in the tissue, the *t*11 isomer may be a substrate for an enzyme (Δ^9-desaturase) that could produce CLA. PUFA are also considered to be healthful because they are reported to aid in blocking the development of coronary heart disease. Concentrations of PUFA were greater in pasture-finished steers than in feedlot-finished steers (Table 4). The atherogenic index (AI) is a composite of the fatty acid composition of a food and a low atherogenic index is considered favorable for human health. The AI of beef from pasture- and feedlot-finished steers did not differ, and was less than 1 (Table 4).

Muscles also differed in their fatty acid profiles. The GR had the greatest concentration of C18:2, which was reflected in total PUFA, as the gracilis had the greatest concentration of PUFA (Table 5). The LM had the greatest concentration of SFA (Table 5), which was reflected in the AI as the LM had the highest AI. None of the muscles, however, had an AI of greater than 1. Muscle differences may be attributable to differences in muscle metabolism and fiber type.

Fatty acid content. The most prevalent fatty acids in tissue include C16:0 and C18:1 as well as C18:2. In beef from pasture-finished steers, total CLA and C18:3n3 content was greater ($P < 0.0001$) than in beef from feedlot-finished steers (Table 6). As a result of its lipid percentage, the LM had the greatest total content of SFA, MUFA, and PUFA (Table 7).

Conclusions. This study showed that 25-OH D_3 had very little impact on lipid composition of beef, but may have an impact on pre-harvest lipid metabolism. The fatty acid composition of beef is dependent upon both the muscle evaluated and diet. CLA and omega-3 fatty acids were greater in beef from the pasture-finished steers, even though the steers in this study received supplement during the finishing period. Feedlot-finished steers had greater concentrations of MUFA and greater total content of SFA, MUFA, and PUFA. Nonetheless, all AI calculated were less than 1, which is low and therefore favorable for human health.

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Table 1. Composition of feedlot-finishing diet.

Feed Ingredient	% of diet, DMB[a]
Dry rolled corn	72.965%
Wet distillers' grains	10.000%
Corn silage	9.955%
Ground hay – brome	2.500%
Urea	1.474%
Potassium chloride	0.966%
Limestone	0.966%
Salt	0.300%
Vitamin A	0.080%
Trace minerals	0.024%
Rumensin 80	0.020%
Molasses	0.750%
Total	100.000%

[a]DMB = Dry Matter Basis

Table 2. Composition and calculated analysis of a by-product feed mix.

Composition	%
Dried distillers' grains with solubles	50.0
Soy hulls	25.0
Wheat middlings	20.9
Molasses	2.5
Calcium carbonate	1.6
Total	100.0
Calculated Analysis	
Dry matter, %	90.1
Crude protein, %	21.8
Calcium, %	0.94
Phosphorus, %	0.67
NE m	0.91
NE g	0.61
TDN, %	85.9

Table 3. Concentrations of C18:3*n*3 and conjugated linoleic acid (CLA) in the gracilis, longissimus, and semimembranosus muscles of co-product- supplemented pasture- and feedlot-finished beef steers.

	(mg/100 mg of fatty acid)	
Diet/Muscle	C18:3*n*3	CLA(C18:2*cis*-9,*trans*11)
Feedlot		
Gracilis	0.00[d]	0.00[c]
Longissimus	0.25[c]	0.19[b]
Semimembranosus	0.01[d]	0.02[c]
SEM	0.04	0.06
Pasture		
Gracilis	0.18[c]	0.30[b]
Longissimus	0.63[a]	0.94[a]
Semimembranosus	0.41[b]	0.82[a]
SEM	0.03	0.06

[abc]Means within a column lacking a common superscript letter are different ($P < 0.05$).

Table 4. Least squares means of fatty acids (mg/100 mg of fatty acid) of steaks from co-product supplemented pasture- and feedlot finished beef steers.

Fatty acid	Pasture ± SEM	Feedlot ± SEM
C14:0	2.43[b] ± 01.2	2.94[a] ± 0.12
C14:1	0.39[b] ± 0.07	0.61[b] ± 0.07
C16:0	26.93[b] ± 1.00	28.49[a] ± 1.00
C16:1	3.28[b] ± 0.16	3.92[a] ± 0.16
C17:0	0.74[b] ± 0.06	0.89[a] ± 0.06
C17:1	0.28[b] ± 0.05	0.59[a] ± 0.05
C18:0	14.13[a] ± 0.24	12.90[b] ± 0.27
C18:1(*t*9 and *t*11)	3.99[a] ± 0.20	0.99[b] ± 0.20
C18:1	32.50[b] ± 0.95	38.19[a] ± 0.97
C18:1(*c*11)	1.03[b] ± 0.01	1.42[a] ± 0.02
C18:2	9.11[a] ± 1.04	7.18[b] ± 1.06
Unknown	0.42[a] ± 0.03	0.07[b] ± 0.03
SFA[c]	44.66 ± 1.10	45.31 ± 1.13
MUFA[c]	41.40[b] ± 1.16	45.72[a] ± 1.18
PUFA[c]	12.15[a] ± 1.30	8.95[b] ± 1.32

[ab]Means within a row lacking a common superscript letter are different ($P < 0.05$).

[c]SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids.

Table 5. Least squares means of fatty acids (mg/100 mg fatty acid) of steaks from the gracilis (GR), longissimus (LM), and semimembranosus (SM) muscles of beef steers.

Fatty acid	GR	LM	SM	SEM
C14:0	2.34[c]	3.11[a]	2.61[b]	0.11
C14:1	0.28[c]	0.70[a]	0.51[b]	0.06
C15:0	0.04[c]	0.40[a]	0.12[b]	0.02
C16:0	27.29	28.47	27.37	1.00
C16:1	3.40[b]	3.79[a]	3.61[a]	0.16
C17:0	0.64[b]	0.91[a]	0.88[a]	0.06
C17:1	0.30[c]	0.56[a]	0.43[b]	0.05
C18:0	13.83	13.69	13.03	0.30
C18:1	35.21	34.08	36.74	1.06
C18:1(*c*11)	1.32[a]	1.11[c]	1.23[b]	0.02
C18:2	10.73[a]	6.99[b]	6.70[b]	1.03
C20:3*n*6	0.24[b]	0.40[a]	0.17[b]	0.06
C20:4	1.54	1.54	1.40	0.21
Unknown	0.15[b]	0.38[a]	0.20[b]	0.03
SFA[c]	44.22[b]	46.66[a]	44.07[b]	1.14
MUFA[c]	42.83	42.93	44.91	1.25
PUFA[c]	12.76[a]	9.99[b]	8.91[b]	1.27
Atherogenic Index	0.66[b]	0.81[a]	0.70[b]	0.04

[abc]Means within a row lacking a common superscript letter are different ($P < 0.05$).

[c]SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids.

Table 6. Least squares means of fatty acids (mg/100 g of tissue) of steaks from co-product supplemented pasture- and feedlot finished beef steers.

Fatty acid	Pasture ± SEM	Feedlot ± SEM
C14:0	49.2 ± 6.3[b]	64.6 ± 6.4[a]
C14:1	8.6 ± 1.8[b]	14.4 ± 1.8[a]
C15:0	4.3 ± 0.8	4.9 ± 0.8
C16:0	534.7 ± 77.9	609.8 ± 78.8
C16:1	65.8 ± 10.1	84.4 ± 10.2
C17:0	15.5 ± 2.7	20.1 ± 2.8
C17:1	6.5 ± 1.8[b]	13.7 ± 1.9[a]
C18:0	280.7 ± 32.5	273.39 ± 33.1
C18:1(*t*9 and *t*11)	81.5 ± 9.7[a]	21.2 ± 9.9[b]
C18:1 and C18:1(*c*11)	626.8 ± 82.8[b]	858.0 ± 83.8[a]
C18:2	147.5 ± 4.0	140.4 ± 5.3
CLA (C18:2*c*9,*t*11)	14.9 ± 2.1[a]	1.5 ± 2.2[b]
C18:3*n*3	8.0 ± 0.6[a]	2.4 ± 0.6[b]
C20:3*n*6	5.4 ± 0.7	4.4 ± 0.7
C20:4	26.9 ± 2.4	26.8 ± 2.5
SFA[c]	884.8 ± 119.4	972.4 ± 120.9
MUFA[c]	789.4 ± 102.7[b]	990.6 ± 104.0[a]
PUFA[c]	204.6 ± 9.6	175.1 ± 10.3

[ab]Means within a row lacking a common superscript letter are different (P < 0.05).

[c]SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids.

Table 7. Least squares means of fatty acids (mg/100 g tissue) of steaks from the gracilis (GR), longissimus (LM), and semimembranosus (SM) muscles of beef steers.

Fatty acid	GR	LM	SM	SEM
C14:0	37.0[c]	80.5[a]	53.2[b]	6.9
C14:1	4.8[c]	18.5[a]	11.2[b]	1.8
C15:0	1.1[b]	10.4[a]	2.4[b]	0.8
C16:0	422.9[c]	738.7[a]	555.2[b]	82.1
C16:1	53.5[c]	99.0[a]	72.7[b]	10.5
C17:0	11.0[c]	24.2[a]	18.3[b]	2.9
C17:1	5.3[c]	15.1[a]	9.8[b]	1.8
C18:0	213.8	356.9	260.4	35.3
C18:1 and C18:1(*c*11)	573.4[b]	886.2[a]	767.6[a]	90.4
C18:1 *t*9 and *t*11	37.2[b]	71.3[a]	45.6[b]	10.1
C18:2	149.2[ab]	160.9[a]	121.8[b]	8.4
CLA (C18:2*c*9,*t*11)	2.6[c]	14.4[a]	7.6[b]	2.2
C18:3*n*3	1.7[b]	10.6[a]	3.3[b]	0.7
C20:3*n*6	3.0[b]	9.2[a]	2.5[b]	0.8
C20:4	21.6[b]	34.7[a]	24.2[b]	2.8
SFA[c]	685.5[b]	1210.5[a]	889.9[b]	127.5
MUFA[c]	673.5[b]	1089.4[a]	907.0[a]	110.7
PUFA[c]	178.6[b]	230.9[a]	160.0[b]	12.7

[abc]Means within a row lacking a common superscript letter are different ($P < 0.05$).

[c]SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, and PUFA = polyunsaturated fatty acids.