Chemical, Fatty Acid and Sensory Characteristics of Beef from Cattle Grazing Forages Supplemented with Soyhulls vs. USDA Choice and Select Beef

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Story in Brief

Increased concerns for a healthier diet have spurred interests in forage-fed beef due to proportions of fatty acids that have exhibited a healthy impact when incorporated into a dietary regimen. Supplementing concentrates to cattle on a forage ration can improve palatability, but can negatively impact the healthier fatty acid profile associated with a forage ration. Therefore, over two consecutive years, steaks from cattle (n = 107) grazing three cool season grazing systems consisting of either orchardgrass pasture or fescue pasture, each with soyhull supplementation, or fescue pasture with no supplementation for a control were compared with USDA Choice and Select steaks obtained from area supermarkets for chemical, fatty acid and sensory characteristics. Steaks from all three forage treatments had more ($P < 0.05$) longissimus conjugated linoleic acid (CLA; 18:2*cis*-9, trans-11) and lower ($P < 0.05$) n-6 to n-3 fatty acid ratios than USDA Choice or Select steaks. Supplementing soyhulls did not decrease ($P > 0.05$) longissimus CLA, and sensory evaluation revealed that the supplemented treatments had improved ($P < 0.05$) beef/brothy and reduced ($P < 0.05$) grassy characteristics when compared to the control. These results suggest supplementing soyhulls to cattle on forage can improve the sensory characteristics of the beef without dramatically hindering the fatty acid profile associated with forage-fed beef.

Introduction

Forage-fed beef has taken a "healthy" role as a marketing strategy due to an increased awareness for a healthier human diet. Typically, beef from cattle on a forage diet has been considered healthy due to either its leanness or a healthier fatty acid profile. In human health, certain fatty acid interests are increased levels of conjugated linoleic acid (CLA), which has exhibited anticarcinogenic properties, and lowering the ratio of n-6 to n-3 fatty acids, which can aid in cardiovascular health (Lee et al., 1989; Whigham et al., 2000). However, forage-fed beef can experience decreased consumer acceptance due to differences in juiciness or tenderness (Muir et al., 1998), and most commonly differing flavor characteristics when compared to grain-fed beef (Melton et al., 1983). Increasing the portion of grain in the diet can allow for improved flavor desirability (Smith et al., 1983).

Supplementation of forage-fed beef can allow for increased gains, enhanced carcass quality, and improved palatability; however, increased incorporation of concentrates in the diet can decrease forage utilization and deleteriously affect the fatty acid profile associated with the healthier aspects of forage-fed beef (French et al., 2000; Griebenow et al., 1997). Therefore, the objectives of this study were to determine if supplementation of soyhulls, a highly digestible fiber source, could allow for improved sensory characteristics without negatively affecting the perceived healthier fatty acid profile commonly present in forage-fed beef.

Experimental Procedures

Animals. For this study, British and British x Continental fall- and spring-born beef steers and heifers (n = 107) were selected from a commercial cowherd at the University of Tennessee Experiment Station, Springhill, TN. Cattle were assessed and chosen based on three divergent biological types for a separate trial. This study was replicated over two consecutive years consisting of 54 animals utilized each year. One heifer was removed from the first year's study due to chronic illness.

After weaning, the randomly chosen calves were stratified across either orchardgrass (*Dactylis glomerata*) predominated pasture (n = 35) supplemented with pelleted soyhulls (Orchard), tall fescue (*Festuca arundinacea* Schreb.) pasture (n =36) with soyhull supplementation (Fescue), or fescue pasture (n = 36) with no supplementation (Control). Utilizing a rotational system, each paddock allowed for 0.5 acre/calf in the fall and spring, and 1 acre/calf in the winter. Pelleted soyhulls were fed to the supplemented treatments and were allocated at 1% BW/calf/day. Adjustments to supplementation were performed every 28 days when the cattle were reweighed. Grazing continued into the summer months (mean days of age = 555), until forage availability started to diminish and cattle had attained a relative degree of finish determined by visual appraisal, whereupon all cattle, within a year, were sent to a commercial slaughtering facility.

After carcasses had chilled for 48 h, a three-rib section (10th to 12th ribs) of the wholesale rib from the right side of each carcass was removed, vacuum-sealed, transported back to the University of Arkansas and aged for an additional 5 days before subsequent analyses.

For comparison to the forage-fed beef, USDA Choice (Choice) and Select (Select) ribeye steaks were randomly chosen from area supermarkets or purveyors to be representative of those typically available to consumers. Unless otherwise specified, the number of USDA Choice and Select steaks were equal in number to those from the forage-fed treatments for individual analyses.

Warner-Bratzler shear force and cooking loss. For Warner-Bratzler shear force (WBS) analysis, rib steaks (1 in thick) were cooked in a convection oven until the internal temperature of each steak was 158°F. After cooking, steaks were allowed to cool to room temperature for approximately 2 h, and upon cooling, five 0.5-in diameter cores were removed from the longissimus muscle from each steak for WBS. Each core was sheared with a Warner-Bratzler shear (WBS) attachment using an Instron (Canton, MA) Universal Testing Machine.

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Cooking loss of the steaks was determined during the cooking process for WBS. After steaks were removed from the vacuum-sealed pouches, each steak was weighed on a balance prior to cooking. Upon completion of cooking, a final weight was obtained for cooking loss calculations.

Chemical analyses. For fatty acid, lipid, and moisture analyses a sub-sample consisting of 14 Choice and 14 Select steaks was utilized. Samples from the forage treatments consisted of the total number of observations in each treatment (n = 36 each).

Percent moisture was obtained by dicing the longissimus muscle of a steak and utilizing approximately a 50-g sample to represent a homogenous portion. Samples were freeze-dried for approximately 96 h. After drying, percentage moisture was calculated, and samples were placed in a commercial blender, ground and stored in a freezer at - 20°F for later determination of total lipids and fatty acid profiles.

Total lipids were obtained using the method as described by Rule (1997). Tissue samples weighing 200 mg were utilized, and lipid extraction was performed with chloroform-methanol, followed by chloroform removal and evaporation to yield the lipid fraction.

For fatty acid analysis, total lipids were extracted by the same method previously described. Fatty acid methyl esters (FAME) were prepared by transmethylation utilizing methanol and HCl as described by Murrieta et al. (2003). Tridecanoic acid (13:0; 1 mg) was used as the internal standard for all samples. Fatty acid methyl esters were analyzed using a Hewlett-Packard 5890 series II gas chromatograph (Hewlett-Packard, Avondale, PA) equipped with a flame ionization detector and a 60-m x 0.25-mm fused silica capillary column (SP-2380; Supelco, Bellefonte, PA).

Taste-panel. Sensory characteristics of the longissimus steaks were obtained by a professional taste-panel at Texas A & M University, College Station, TX. A sub-sample consisting of 24 steaks per forage treatment and 14 Choice and 14 Select steaks (n = 100) was utilized for determination of sensory characteristics. A six-member taste panel was utilized to determine aromatic, feeling-factor, taste and aftertaste, and textural sensory characteristics. The aromatic, feeling factor, taste and aftertaste sensory characteristics were scored on a 15-point scale (0 = not detected; 15 = extremely intense). Textural sensory characteristics were scored on an 8-point scale (1 = extremely dry, extremely tough, abundant, extremely bland; 8 = extremely juicy, extremely tender, none, extremely intense).

Statistical analysis. Comparisons of steaks from the three forage treatments and USDA Choice and Select steaks by one-way analysis of variance blocked by year were performed using PROC GLM in SAS (SAS Inst., Inc., Cary, NC.). Mean generation and separation was executed using LSMEANS with the PDIFF and STDERR options of SAS.

Results and Discussion

Least squares means for longissimus steak cooking loss, percentage lipid and moisture, and WBS are reported in Table 1. Choice steaks had the highest ($P < 0.05$) lipid percentage and the lowest ($P < 0.05$) moisture percentage compared to all other treatments. Fescue and Orchard steaks had higher ($P < 0.05$) lipid percentages than Control or Select steaks. Control steaks had lesser ($P < 0.05$) cooking losses than Choice steaks, but did not differ ($P > 0.05$) from the other treatments. The WBS force values for Choice were lowest ($P < 0.05$), indicating improved tenderness; however, steaks from all treatments had less than 13.2 lb (6 kg) shear force, an index of tenderness, indicating all treatments could be classified as tender.

Longissimus fatty acid least squares means are reported in Table 2. Choice and Select steaks had increased ($P < 0.05$) 18:2cis- 9,12 percentages, and had decreased ($P < 0.05$) 18:2*cis*- 9, trans-11 (CLA) and 18:3*cis*- 9,12,15 percentages compared to the forage treatments. In fact, forage treatments had greater than twice the CLA content than Choice or Select steaks. There were no differences ($P > 0.05$) between forage treatments for CLA, but the Control steaks did have increased ($P < 0.05$) 18:3*cis*- 9,12,15 percentages. This increase could be due to increased forage ingestion associated with no supplemented feed. Therefore, the increased 18:3*cis*- 9,12,15 percentages in Control lean tissue is probably a result of increased ingestion of fescue forage, which typically has a high percentage of 18:3*cis*-9,12,15. The Control steaks also had higher ($P < 0.05$) percentages of 20:5*cis*- 5,8,11,14,17 and 22:5*cis*- 7,10,13,16,19 than all other treatments; thus allowing the Control steaks to have a lower ($P < 0.05$), more desirable, n-6 to n-3 fatty acid ratio than all other treatments. However, the Fescue and Orchard longissimus steaks did have a lower ($P < 0.05$) n-6 to n-3 ratio than Choice or Select steaks.

Sensory profile characteristics are reported in Table 3. Although Control longissimus steaks had the lowest ($P < 0.05$) beef/brothy sensory characteristic, there were no differences ($P > 0.05$) between Choice, Fescue, Orchard or Select longissimus steaks, indicating an improved beef flavor with soyhull supplementation. Furthermore, longissimus steaks from Fescue and Orchard had lower ($P < 0.05$) grassy sensory values than the Control, and did not differ ($P > 0.05$) from Choice or Select steaks. There were no differences ($P > 0.05$) between treatments for juiciness, and even though longissimus steaks from Choice were rated more tender ($P < 0.05$) for overall tenderness, there were no differences ($P > 0.05$) between forage treatments or Select steaks.

Implications

Implementing soyhull supplementation on a forage-feeding regimen can allow for improved flavor characteristics to levels similar to Choice steaks while maintaining heightened CLA concentrations and a more acceptable n-3 fatty acid profile compared to typical supermarket steaks available to the consumer.

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Table 1. Least-squares means for longissimus cooking loss, lipid percentage, moisture percentage and Warner-Bratzler shear force (WBS) by treatment[a].

	Treatment				
Item	Control	Fescue	Orchard	Choice	Select
Cooking loss[b]	27.54 ± 0.77[x]	27.13 ± 0.78[x]	28.77 ± 0.79[wx]	30.14 ± 0.78[w]	29.28 ± 0.78[wx]
Lipid %[c]	2.56 ± 0.27[y]	4.72 ± 0.27[x]	5.00 ± 0.27[x]	6.93 ± 0.42[w]	3.29 ± 0.43[y]
Moisture %[d]	74.43 ± 0.26[w]	71.92 ± 0.26[x]	71.70 ± 0.27[x]	69.38 ± 0.42[y]	72.38 ± 0.42[x]
Shear (lb)	10.23 ± 0.20[xy]	11.46 ± 0.20[w]	11.42 ± 0.20[wx]	8.12 ± 0.44[z]	9.88 ± 0.20[y]

[a] **Cooking loss and WBS: Choice, Control, Fescue, Orchard and Select (n = 36 each; n = 179 total)**
Lipid and moisture %: Control, Fescue and Orchard (n = 36 each); Choice and Select (n = 14 each)
Total sample (n = 135)
[b] Cooking loss calculated as: (Fresh weight – Cooked weight) / Fresh weight x 100
[c] Lipid percentage calculated as: Lipid weight / Tissue weight x (100 – percent moisture)
[d] Moisture percentage calculated as: (Wet weight – Dry weight) / Wet weight x 100
[wxyz] Within a row, means without a common superscript letter differ ($P < 0.05$)

Table 2. Least-squares means for individual fatty acids of longissimus muscle by treatment (n = 135)[a].

	Treatment				
Fatty acid[a]	Control	Fescue	Orchard	Choice	Select
12:0	0.29 ± 0.05	0.30 ± 0.06	0.26 ± 0.06	0.35 ± 0.08	0.28 ± 0.08
14:0	1.20 ± 0.07[x]	1.41 ± 0.08[wx]	1.33 ± 0.08[wx]	1.61 ± 0.13[w]	1.56 ± 0.13[w]
14:1*cis*-9	0.54 ± 0.11[y]	0.99 ± 0.11[w]	0.86 ± 0.11[wx]	0.56 ± 0.18[xy]	0.45 ± 0.18[xy]
15:0	2.58 ± 0.11[w]	1.44 ± 0.11[y]	1.83 ± 0.11[x]	1.89 ± 0.18[x]	2.04 ± 0.18[x]
15:1*cis*-9	0.33 ± 0.02[w]	0.18 ± 0.02[x]	0.28 ± 0.02[w]	0.16 ± 0.03[x]	0.18 ± 0.03[x]
16:0	22.80 ± 0.29[x]	25.28 ± 0.29[w]	24.50 ± 0.30[w]	25.09 ± 0.47[w]	22.90 ± 0.47[x]
16:1*cis*-9	2.75 ± 0.09	3.13 ± 0.09	2.97 ± 0.09	3.06 ± 0.15	2.98 ± 0.15
16:1*trans*-9	0.94 ± 0.03[w]	0.68 ± 0.03[x]	0.72 ± 0.04[x]	0.45 ± 0.06[y]	0.50 ± 0.06[y]
17:0	2.00 ± 0.14[w]	1.51 ± 0.13[x]	2.09 ± 0.14[w]	1.76 ± 0.22[wx]	1.76 ± 0.22[wx]
17:1*cis*-9	1.01 ± 0.03[x]	0.93 ± 0.03[xy]	0.84 ± 0.03[y]	0.87 ± 0.05[y]	1.13 ± 0.05[w]
18:0	13.70 ± 0.23[w]	13.01 ± 0.23[x]	12.91 ± 0.23[x]	11.68 ± 0.37[y]	11.49 ± 0.37[y]
18:1*cis*-9	30.97 ± 0.47[z]	34.98 ± 0.47[w]	34.61 ± 0.47[wx]	32.88 ± 0.75[xy]	31.90 ± 0.75[yz]
18:2*cis*-9,12	7.15 ± 0.32[y]	6.47 ± 0.32[y]	6.85 ± 0.32[y]	9.85 ± 0.55[x]	11.52 ± 0.53[w]
18:2*cis*-9, *trans*-11 (CLA)	0.69 ± 0.02[w]	0.70 ± 0.02[w]	0.63 ± 0.02[w]	0.25 ± 0.03[x]	0.26 ± 0.03[x]
18:3*cis*-6,9,12	0.04 ± 0.01[x]	0.06 ± 0.00[w]	0.05 ± 0.01[wx]	0.03 ± 0.02[x]	0.04 ± 0.01[wx]
18:3*cis*-9,12,15	2.12 ± 0.07[w]	1.28 ± 0.07[x]	1.17 ± 0.07[x]	0.39 ± 0.12[y]	0.58 ± 0.12[y]
20:4*cis*-5,8,11,14	3.55 ± 0.15[w]	2.54 ± 0.16[x]	2.61 ± 0.16[x]	3.60 ± 0.26[w]	3.79 ± 0.25[w]
20:5*cis*-5,8,11,14,17	1.27 ± 0.04[w]	0.38 ± 0.04[y]	0.50 ± 0.04[x]	0.28 ± 0.06[y]	0.61 ± 0.06[x]
22:0	0.98 ± 0.06[w]	0.70 ± 0.06[x]	0.86 ± 0.06[wx]	0.90 ± 0.13[wx]	0.92 ± 0.11[wx]
22:5*cis*-7,10,13,16,19	1.53 ± 0.05[w]	0.80 ± 0.05[yz]	1.01 ± 0.05[x]	0.64 ± 0.08[z]	0.99 ± 0.08[xy]
22:6*cis*-4,7,10,13,16,19	0.16 ± 0.01[w]	0.08 ± 0.01[x]	0.09 ± 0.01[x]	0.08 ± 0.01[x]	0.14 ± 0.01[w]
PUFA	15.07 ± 0.46[w]	10.03 ± 0.46[y]	12.95 ± 0.46[x]	12.90 ± 0.69[x]	14.77 ± 0.69[wx]
SFA	43.08 ± 0.37	43.40 ± 0.37	42.95 ± 0.37	43.48 ± 0.55	42.05 ± 0.55
PUFA / SFA	0.35 ± 0.01[w]	0.23 ± 0.01[y]	0.30 ± 0.01[x]	0.30 ± 0.02[x]	0.35 ± 0.02[w]
n - 3	4.90 ± 0.13[w]	2.21 ± 0.13[y]	2.81 ± 0.13[x]	1.46 ± 0.19[z]	2.37 ± 0.19[xy]
n - 6	9.37 ± 0.41[x]	7.03 ± 0.41[y]	9.42 ± 0.41[x]	11.16 ± 0.62[w]	12.09 ± 0.62[w]
n - 6 / n - 3	1.92 ± 0.32[z]	3.19 ± 0.32[y]	3.38 ± 0.32[y]	8.24 ± 0.48[w]	5.69 ± 0.48[x]

[a] Control, Fescue and Orchard (n = 36 each); Choice and Select (n = 14 each)
[b] Fatty acid percents expressed as proportion of all peaks observed by GLC
PUFA = Fatty acids with 2 or more double bonds; SFA = Fatty acids with no double bonds;
n-3 = 18:3*cis*- 9,12,15; 20:5*cis*-5,8,11,14,17; 22:5*cis*-7,10,13,16,19; 22:6*cis*-4,7,10,13,16,19
n-6 = 18:2*cis*-9,12; 18:3*cis*-6,9,12; 20:4*cis*-5,8,11,14
[wxyz] Within a row, means without a common superscript letter differ ($P < 0.05$)

Table 3. Least-squares means for sensory characteristics of longissimus muscle by treatment (n = 100)[a].

	Treatment				
Item	Control	Fescue	Orchard	Choice	Select
Aromatics[b]					
Beef/brothy	4.46 ± 0.08[x]	4.73 ± 0.08[w]	4.80 ± 0.08[w]	4.94 ± 0.10[w]	4.86 ± 0.10[w]
Beef fat	1.42 ± 0.06[y]	1.58 ± 0.06[xy]	1.61 ± 0.06[x]	1.82 ± 0.08[w]	1.59 ± 0.08[xy]
Serumy/bloody	1.49 ± 0.09	1.61 ± 0.09	1.58 ± 0.09	1.47 ± 0.12	1.51 ± 0.12
Grainy/cowy	0.0	0.0	0.0	0.0	0.0
Cardboard	0.11 ± 0.03	0.08 ± 0.03	0.10 ± 0.03	0.06 ± 0.04	0.10 ± 0.04
Painty	0.0	0.0	0.0	0.0	0.0
Fishy	0.0	0.0	0.0	0.0	0.0
Liver	0.27 ± 0.07	0.21 ± 0.07	0.26 ± 0.07	0.47 ± 0.09	0.25 ± 0.09
Soured	0.0	0.0	0.0	0.0	0.0
Browned/burnt	0.73 ± 0.10	0.83 ± 0.10	0.94 ± 0.10	0.80 ± 0.13	0.89 ± 0.13
Grassy	1.11 ± 0.08[w]	0.80 ± 0.08[x]	0.78 ± 0.08[x]	0.60 ± 0.11[x]	0.71 ± 0.11[x]
Milky/oily	0.61 ± 0.06	0.64 ± 0.06	0.69 ± 0.06	0.52 ± 0.08	0.48 ± 0.08
Old/putrid	0.10 ± 0.03	0.02 ± 0.03	0.05 ± 0.03	0.04 ± 0.03	0.02 ± 0.03
Feeling factors[b]					
Metallic	2.68 ± 0.04	2.81 ± 0.04	2.76 ± 0.04	2.71 ± 0.05	2.73 ± 0.05
Astringent	2.37 ± 0.03[wx]	2.45 ± 0.03[x]	2.42 ± 0.03[x]	2.28 ± 0.04[w]	2.39 ± 0.04[wx]
Tastes[b]					
Salt	1.98 ± 0.02	2.03 ± 0.02	2.00 ± 0.02	2.02 ± 0.02	2.01 ± 0.02
Sour	2.51 ± 0.05	2.52 ± 0.05	2.60 ± 0.05	2.48 ± 0.06	2.51 ± 0.06
Bitter	2.45 ± 0.05	2.43 ± 0.05	2.39 ± 0.05	2.29 ± 0.07	2.35 ± 0.07
Sweet	0.40 ± 0.04	0.50 ± 0.04	0.43 ± 0.04	0.59 ± 0.05	0.47 ± 0.05
Aftertastes[b]					
Sour	0.99 ± 0.07	0.92 ± 0.07	1.00 ± 0.07	1.08 ± 0.09	1.09 ± 0.09
Acid	1.27 ± 0.10	1.28 ± 0.10	1.19 ± 0.10	1.09 ± 0.14	1.26 ± 0.14
Bitter	0.90 ± 0.08	0.94 ± 0.08	0.82 ± 0.08	0.68 ± 0.11	0.83 ± 0.11
Liver	0.09 ± 0.03	0.03 ± 0.03	0.07 ± 0.03	0.14 ± 0.04	0.06 ± 0.04
Browned/burnt	0.14 ± 0.07	0.14 ± 0.07	0.20 ± 0.07	0.18 ± 0.08	0.25 ± 0.08
Metallic	1.72 ± 0.06[x]	1.89 ± 0.06[wx]	1.91 ± 0.06[w]	1.79 ± 0.08[wx]	2.02 ± 0.08[w]
Grassy	0.26 ± 0.05[w]	0.11 ± 0.05[x]	0.10 ± 0.05[x]	0.04 ± 0.06[x]	0.13 ± 0.06[x]
Milky/oily	0.30 ± 0.06	0.38 ± 0.06	0.37 ± 0.06	0.24 ± 0.08	0.23 ± 0.08
Lipburn	0.38 ± 0.03	0.33 ± 0.03	0.30 ± 0.03	0.34 ± 0.04	0.36 ± 0.03
Chemical	0.01 ± 0.02	0.03 ± 0.02	0.0	0.04 ± 0.02	0.01 ± 0.02
Serumy/bloody	0.25 ± 0.06	0.25 ± 0.06	0.25 ± 0.06	0.18 ± 0.07	0.13 ± 0.07
Sweet	0.01 ± 0.02	0.07 ± 0.02	0.0	0.04 ± 0.03	0.01 ± 0.03
Old/putrid	0.0	0.0	0.0	0.0	0.0
Textures[c]					
Juiciness	4.95 ± 0.11	5.05 ± 0.11	5.02 ± 0.11	5.26 ± 0.15	5.10 ± 0.15
Myofibrillar tenderness	5.35 ± 0.17[x]	5.36 ± 0.17[x]	5.37 ± 0.17[x]	6.49 ± 0.22[w]	5.80 ± 0.22[x]
Connective tissue	6.19 ± 0.17[xy]	6.23 ± 0.17[xy]	6.01 ± 0.17[y]	7.14 ± 0.22 [w]	6.60 ± 0.22[wy]
Overall tenderness	5.36 ± 0.17[x]	5.36 ± 0.17[x]	5.35 ± 0.17[x]	6.51 ± 0.22[w]	5.79 ± 0.22[x]

[a] Sample consisted of sub-sample: Control, Fescue and Orchard (n = 24 each); Choice and Select (n = 14 each)

[b] 0 to 15: 0 = absent, 15 = extremely intense

[c] 1 to 8: 1 = extremely dry, extremely tough, abundant, extremely bland; 8 = extremely juicy, extremely tender, none, extremely intense

[wxy] Within treatment or biological type, within a row, means with different superscripts differ ($P < 0.05$)