Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 1 *Cattleman's Day (1993-2014)*

Article 1175

1981

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Nutritional Effects of Beef Connective Tissue Characteristics and Eating Qualities

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Summary

We compared taste panel and connective tissue characteristics of beef fed a high energy diet with beef fed grass. The high energy diet produced higher USDA quality and yield grades, more rapid weight gain, and increased connective tissue collagen synthesis and breakdown. But, it did not consistently improve taste panel and shear characteristics over grass-feeding.

Introduction

Muscles and muscle cells are surrounded by layers of connective tissue, which are comprised mainly of the protein collagen. The connective tissue network shrinks when meat is cooked, and the shrinkage either toughens or tenderizes the cooked meat, depending on the strength of collagen fibers. In tender muscle from young animals, collagen fibers contain very few heat-stable bonds, so they fall apart and gel upon cooking. As animals age, collagen fibers are held together more strongly by heat-stable bonds, then they remain as "chewy", tough fibers rather than falling apart on cooking. Hydroxyproline, a specific amino acid, occurs only in collagen, so measures of hydroxyproline also are measures of collagen. As the connective tissue collagen matures, it becomes more difficult to solubilize. Salt-soluble collagen represents young, newly synthesized collagen, while acid-soluble collagen is more mature. Additionally, the amount of hydroxyproline in the blood indicates how fast collagen is broken down and replaced. We studied the effects of high energy and grass diets on beef eating quality, collagen chemical characteristics, and blood hydroxyproline levels.

Experimental Procedure

We assigned 18 Hereford steers of similar age and nutritional background to three treatment groups: group I was slaughtered in October directly off bluestem pasture at 19 to 20 months of age; group II was slaughtered at the same age, but after 120 days on a 90% concentrate diet; and group III was pastured until October, then fed 90% concentrate for 126 days and slaughtered at 23 to 24 months of age. The Longissimus (loin eye) and Biceps femoris (outside round) muscles were removed 24 hr postmortem, vacuum packaged, and stored for 5 days before being cut into steaks.

Blood hydroxyproline was measured during the feeding period and total salt-and acid-soluble collagen was measured on Longissimus and Biceps femoris muscles.

Cooked loin eye and outside round steaks were evaluated by a trained taste panel and Warner-Bratzler shear.

Results

Cattle on high energy diets had higher quality and yield grades and weighed more than cattle fed grass only (Table 7.1).

Figure 7.1 shows changes in free (non-protein) hydroxyproline in the blood of steers with increasing time on a high energy diet. The first six weeks, muscle growth was rapid and collagen turnover rapid. Later, fat deposition predominated and collagen replacement slowed, as indicated by declining hydroxyproline.

As shown in Table 7.2, collagen in loin eye steaks from cattle fed the high energy diets was more readily soluble than collagen from grass-fed cattle (group I). Collagen synthesis was accelerated by a high energy diet. Loin eye steaks from the three groups did not differ in total collagen, Warner-Bratzler shear force (Table 7.3), or taste panel ratings for shear tenderness, juiciness, and flavor intensity. Outside round steaks from grass-fed steers were juicier than those from steers fed a high energy diet (groups II and III). As we expected, collagen was much higher in outside round muscles than in loin eye. High-energy feeding did not consistently improve taste panel tenderness, shear force, or collagen solubility of outside round steaks.

In this study grass finished cattle yielded acceptable taste panel scores. Feeding did not consistently improve taste or shear tenderness.

Table 7.1. Means for carcass traits of cattle from three nutritional regimens.

Carcass traits	Nutritional regimens		
	Group I Grass	Group II Fed	Group III Grass and Fed
Quality grade[a]	Standard17[b]	Good60[c]	Choice07[d]
Hot carcass wt., lb	377.3 [b]	598.2 [c]	591.2 [c]
Yield grade[a]	1.60[b]	2.85[c]	2.91[c]

[a]Based on descriptions included in USDA (1975) beef grading standards.

[b,c,d]Means for the same trait bearing a common superscript letter do not differ (P>.05).

Table 7.2. Means for collagen characteristics of *longissimus* (loin eye) and *biceps femoris* (outside round) muscles from cattle fed three nutritional regimens.

Intramuscular collagen	Nutritional regimens: Group I Grass	Group II Fed	Group III Grass and fed
	Longissimus		
Collagen content (mg/g)			
Fresh tissue	3.88[a]	4.26[a]	4.28[a]
Moisture and fat free	17.62[a]	18.22[a]	18.41[a]
Percent solubility[c]			
Salt soluble	1.99[a]	2.48[b]	2.22[a,b]
Acid soluble	3.00[a]	2.80[a]	3.86[b]
Salt + Acid soluble	4.99[a]	5.28[a]	6.08[b]
	Biceps femoris		
Collagen content (mg/g)			
Fresh tissue	8.53[a,b]	9.12[a]	7.74[b]
Moisture and fat free	45.70[a]	44.71[a]	36.46[b]
Percent solubility[c]			
Salt soluble	1.20[a,b]	1.29[a]	1.05[b]
Acid soluble	2.30[a]	2.42[a]	2.98[a]
Salt + Acid soluble	3.50[a]	3.71[a]	4.03[a]

[a,b]Means in the same row bearing a common superscript letter do not differ (P>.05).

[c]Amount of salt-soluble collagen and acid-soluble collagen in meat samples are used as an indication of collagen maturity; salt-soluble collagen contains newly synthesized collagen, while acid-soluble collagen is slightly older than salt-soluble collagen.

Table 7.3. Means for taste panel ratings and Warner-Bratzler shear force values of longissimus (loin eye) and biceps femoris (outside round) steaks from cattle fed three nutritional regimens.

Trait	Nutritional regimens: Group I Grass	Group II Fed	Group III Grass and fed
	Longissimus		
Overall tenderness	5.9[b]	6.1[b]	6.6[b]
Connective tissue amount	6.3[b]	6.6[bc]	7.2[c]
Flavor intensity	6.1[b]	6.3[b]	6.4[b]
Juiciness	6.5[b]	6.0[b]	6.3[b]
Shear force, lb	7.0[b]	7.0[b]	5.9[b]
	Biceps femoris		
Overall tenderness	5.6[b]	5.1[c]	5.7[b]
Connective tissue amount	5.0[bc]	4.5[c]	5.3[b]
Flavor intensity	6.3[b]	6.3[b]	6.3[b]
Juiciness	6.7[b]	5.8[c]	5.6[c]
Shear force, lb	10.1[b]	12.3[c]	10.8[bc]

[a]Means based on 8-point rating scale 8 = extremely tender, intense flavor, juicy or no connective tissue; 1 = extremely tough, bland flavor, dry or abundant connective tissue.

[b,c]Means in the same row bearing a common superscript letter do not differ (P>.05).

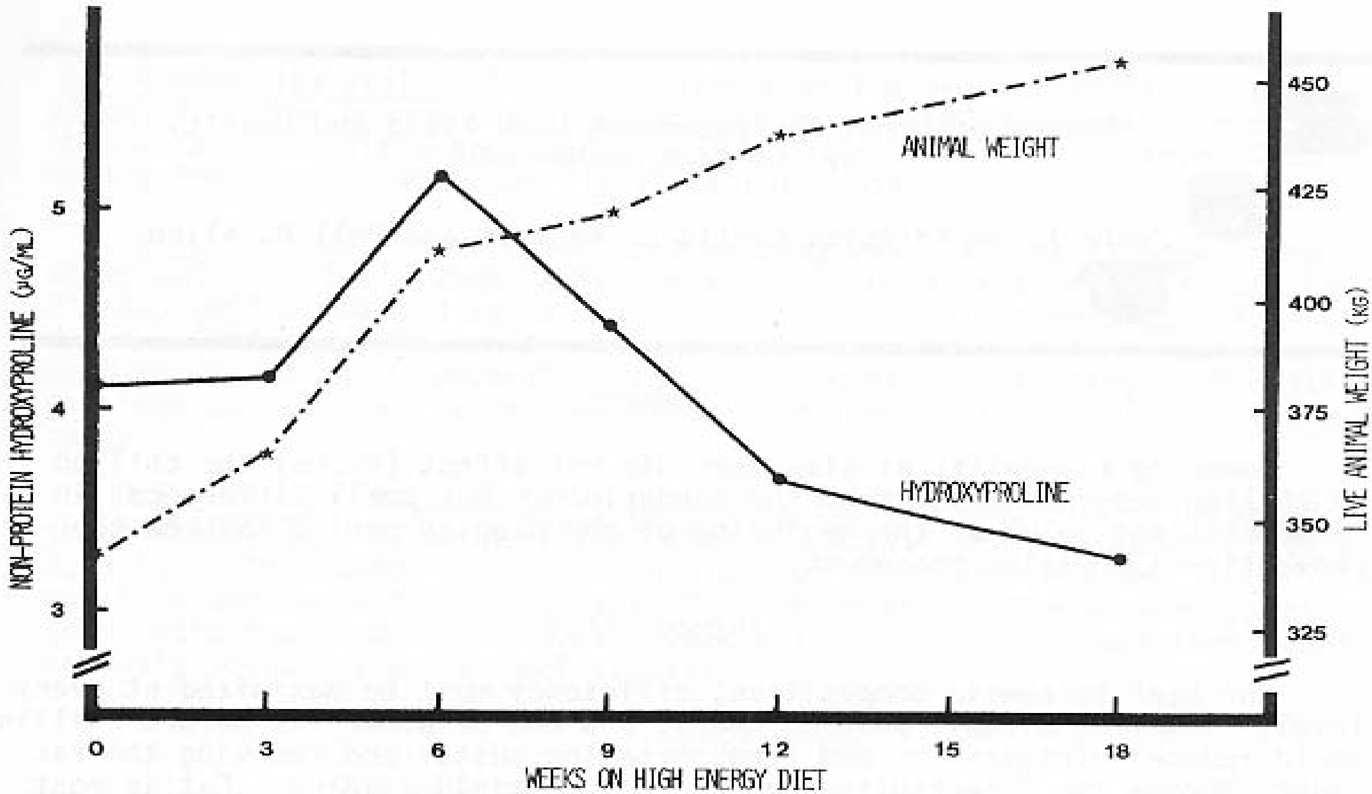

Figure 7.1. Effect of high energy diet on the blood plasma non-protein hydroxyproline and live animal weight of group III cattle.

Beef Tenderness and Collagen

Muscles and muscle cells are surrounded by layers of connective tissue, comprised mainly of the protein, collagen. When meat is cooked, this connective tissue network shrinks. This shrinkage has either a toughening or tenderizing effect on the cooked meat. In tender muscle from young animals, collagen fibers contain very few heat stable bonds, so fibers fall apart and gel upon cooking. In older animals, the collagen fibers are held together by heat stable bonds. The cooked collagen fibers remain intact as "chewy", tough fibers.