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NUTRITIONAL REGIME EFFECTS ON QUALITY AND YIELD CHARACTERISTICS OF BEEF[1,2]

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SUMMARY

Quality and yield characteristics of 38 crossbred steer carcasses were evaluated to measure the effects of four nutritional regimes: grass-fed = winter growing ration (2.18 Mcal ME/kg), followed by summer grazing; short-fed = same as grass-fed, followed by 49 days in drylot on a high grain ration (3.11 Mcal ME/kg); long-fed = same as short-fed, except fed 98 days in drylot; and forage-fed = same as grass-fed, followed by 98 days in drylot on a high forage ration (2.84 Mcal ME/kg).

Higher marbling scores and quality grades and a whiter external fat resulted from increased feeding. Lean texture did not differ ($P<.05$) among feeding regimes, but tended to be finer in longer fed cattle. Bone maturity increased over a 98-day feeding period, but remained well within the A maturity range. Longer feeding increased carcass weight, fat thickness, ribeye area, internal fat and numerical yield grade and reduced cooler shrinkage. All taste panel responses (tenderness, desirability of flavor of lean and fat and juiciness) to *longissimus* samples favored longer fed beef. Generally, nutritional regime did not affect shear force measurement, however, some differences in shear force were noted in *biceps femoris* muscle. Carcasses from cattle fed the longest time and the highest plane of nutrition had the most desirable quality and palatability characteristics. This study indicates that carcasses from cattle fed a high quality ration for a certain period of time will be of acceptable palatability regardless of marbling level or quality grade.

(**Key Words**: Beef, Nutritional Regimes, Quality, Yield.)

INTRODUCTION

Fluctuating feed grain prices have generated considerable interest in alternative feeding regimes when weather, export agreements, or other factors make feeding grain to cattle unprofitable. Due to relative cost inputs, alternative systems will likely involve large quantities of roughages. These systems may range from finishing on grass only, growing on grass and then finishing in drylot for different lengths of time, or feeding higher roughage rations in drylot.

Increased slaughter of pasture-finished cattle, cattle fed high concentrate rations for shorter periods and cattle fed high roughage feeds in drylot has caused producers, packers, purveyors and retailers to question the carcass characteristics of beef from such cattle. This type of beef was a minor proportion of the total beef supply during the 1960's and early 1970's; therefore, little current research elucidating carcass traits of beef fed in the above manners is available. This study summarizes carcass, shear force and taste panel characteristics of beef produced under various feeding regimes.

MATERIALS AND METHODS

Thirty-eight crossbred calves born at the USDA Meat Animal Research Center, Clay Center, Nebraska, were used. Calves were castrated at birth and remained on bromegrass and bluestem pasture with their dams until weaning at six months of age. For the next 75 days, they received a ration of 65% corn silage (IRN 3-02-824), 15% alfalfa haylage (IRN 3-08-151) and 20% cracked corn (IRN 4-02-932) and soybean meal (IRN 5-04-604). At the end of this period, calves were implanted with Ralgro

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(36 mg zeranol). All steers were wintered on ration 1 (table 1) for 134 days before grazing on bromegrass and bluestem pasture for 133 days and were fed no additional concentrate during the grazing period.

Ten steers were randomly selected for slaughter at the end of the grazing period. The remaining 28 steers were randomly assigned to either a short-, long- or forage-fed finishing program in drylot. The short-fed group (10 steers) was fed ration 3 for 49 days (table 1); long- (eight steers) and forage-feds (10 steers) received rations 3 and 2, respectively, for 98 days (table 1). As each feeding period ended, the steers were transported to the Kansas State University meat laboratory for slaughter.

Hot carcass weights were obtained about 1.5 hr postmortem and carcasses were chilled at 3 C for 48 hr before collecting USDA quality and yield grade factors and other carcass data. The *longissimus* (L) (loin section), *semitendinosus* (ST), *biceps femoris* (BF) and *semimembranosus* (SM) muscles were excised intact from each carcass half. A 3.0 cm thick steak from each muscle was removed, vacuum packaged and stored at −26 C for taste panel and shear force determinations. Maximum storage time for L, ST, BF and SM steaks was 34 days for grass- and short-fed, 53 days for long-fed and 73 days for forage-fed samples.

Steaks were thawed at 2 C for 24 hr, removed from the vacuum package, rinsed, blotted, weighed, and cooked in a rotary oven at 163 C to an internal temperature of 66 C. Internal temperature was monitored by a cooking thermometer in the geometric center of each steak.

Taste panel responses were obtained on the L muscle and an external fat sample from the same steak. Evaluations for tenderness, juiciness and desirability of muscle and fat flavor were solicited from a 6-member, trained panel using a 9-point scale (table 4) for each response. Panelists were selected and trained by presenting samples of differing degrees of juiciness and tenderness and evaluating individual sensitivity to differences by use of triangle comparisons (Kramer and Twigg, 1970).

Panelists were positioned randomly in individual booths, served half of a 1.91 cm diameter core and instructed to expectorate each masticated sample and rise their mouths with water between samples. Five muscle samples were presented in randomized order along with two fat samples and no more than two panels were conducted daily. Choice grade L muscle samples were prepared in the same manner, with one preceding each panel sitting as a preparatory sample and the other (from the same carcass) incorporated as a "hidden" reference to serve as a continual check on the consistency of panel members.

Using the L muscle taste panel steaks and steaks from the ST, SM and BF muscles, six 1.25 cm diameter cores were removed with a drill press unit (Kastner and Henrickson, 1969) and sheared once using a Warner-Bratzler apparatus.

TABLE 1. RATION INGREDIENTS AND APPROXIMATE ANALYSIS

Ingredient	Internat'l Ref. No.	Ration 1	Ration 2	Ration 3
Corn silage, %	3-02-824	48.0	40.0	.0
Alfalfa haylage, %	3-08-151	50.0	20.0	20.0
Cracked corn, %	4-02-932	.0	36.0	75.2
Supplement[a], %		2.0	4.0	4.8
Approximate ration composition, dry matter basis[b]				
Dry matter, %		44.9	60.0	81.2
Crude protein, %		14.6	13.0	13.0
Metabolizable energy, Mcal/kg		2.18	2.84	3.11

[a]Soybean meal (Ref. No. 5-04-604) supplement plus calcium, phosphorus, vitamin A and chlortetracycline. Block salt and a mixture of 1/3 loose salt, 1/3 limestone and 1/3 dicalcium phosphate were also available (free access).

[b]Nutrient composition based on tabular values (NRC, 1963) supplemented with limited approximate analysis.

The experimental design was completely randomized with respect to assignment of animals to treatments. Data were analyzed using analysis of variance and resultant F-test. To determine differences between means, the least significant difference was utilized (Snedecor and Cochran, 1973).

RESULTS AND DISCUSSION

Carcass Characteristics. Increasing length of feeding and nutritional plane appeared to enhance carcass quality characteristics. Carcass quality characteristics tended to be more desirable in cattle fed either a higher grain or forage ration for 98 days (table 2). Although differences ($P<.05$) existed in bone maturity scores among nutritional regimes, all scores were well within the A maturity range. Lean maturity scores (color) did not differ among nutritional regimes; all were within the A maturity grouping. Neither bone nor lean maturity affected final quality grade. No differences ($P<.05$) were noted in lean texture of the L muscle; however, lean texture tended to be finer in longer fed cattle.

External fat whitened as feeding period increased (table 2). Carcasses from grass-fed cattle had the yellowest ($P<.05$) fat. Color of fat from long-fed carcasses was whiter ($P<.05$) than short-fed carcasses, but did not differ from forage-fed carcasses. These results agree with those of McCone (1951), Brown (1954), McCormick *et al.* (1958), Malphrus *et al.* (1962) and Kropf *et al.* (1975), who all reported yellower fat on carcasses from grass-fed cattle than on carcasses from cattle fed in drylot.

Marbling scores and quality grade increased with length of feeding (table 2). Carcasses from forage-fed and long-fed cattle had the most marbling; short-fed, intermediate; and grass-fed, the least. Cattle fed 98 days on either a high grain or forage ration had an average quality grade of low Choice. Carcasses from grass-fed steers barely graded low Good. These results agree with those reported by McCone (1951), Weber *et al.* (1951), McCormick *et al.* (1958), Henrickson *et al.* (1965) and Klosterman *et al.* (1965).

Actual and adjusted fat thicknesses were lowest ($P<.05$) for carcasses from grass- and short-fed cattle and highest ($P<.05$) for carcasses from long- and forage-fed cattle (table 3). Godbey *et al.* (1959), Henrickson *et al.* (1965) and Klosterman *et al.* (1965) reported similar observations. Ribeye area (table 3) of carcasses from grass-fed cattle was smaller ($P<.05$) than from short- and long-fed cattle, but did not differ from carcasses of forage-fed cattle. Weight gain during grain feeding for 49 days possibly resulted from increased muscle size, whereas gain differences from 49 to 98 days may be attributed to increased fat deposition.

Kidney, pelvic and heart fat (KPH) generally increased with length of feeding (table 3). KPH percentages were less ($P<.05$) for carcasses from grass- and short-fed cattle than for carcasses from forage-fed cattle. KPH percentages did not differ ($P<.05$) between carcasses from short- and long-fed cattle, but tended to be higher in long-fed cattle.

Carcass weight increased ($P<.05$) with length of feeding (table 3). Grass-fed cattle had the lightest ($P<.05$) carcasses; short-fed, intermedi-

TABLE 2. MEAN BEEF CARCASS QUALITY CHARACTERISTICS BY NUTRITIONAL REGIME

Item	Grass-fed	Short-fed	Long-fed	Forage-fed
Bone maturity[d]	A^{38} a	A^{41} ab	A^{49} b	A^{48} b
Lean maturity[d]	A^{49}	A^{48}	A^{46}	A^{51}
Lean texture[e]	5.0	4.8	3.5	3.9
Fat color[f]	2.0[c]	1.5[b]	1.2[a]	1.3[ab]
Marbling score[d]	Tr^{83} a	Sl^{56} ab	Sm^{75} c	Sm^{49} bc
Quality grade[d]	Gd^{03} a	Gd^{54} ab	Ch^{14} c	Ch^{03} bc

[a,b,c]Means within same row with same or no superscript do not differ ($P>.05$).

[d]01–33 = low, 34–66 = average, 67–100 = high. Inconsistencies between quality grade and marbling score due to averaging.

[e]10-point scale (10 = extremely coarse, 1 = extremely fine).

[f]5-point scale (5 = extremely yellow, 1 = white).

TABLE 3. MEAN CARCASS YIELD CHARACTERISTICS OF BEEF BY NUTRITIONAL REGIME

Item	Grass-fed	Short-fed	Long-fed	Forage-fed
Actual 12th rib fat, cm	.58[a]	.66[a]	1.12[b]	1.29[b]
Adjusted 12th rib fat, cm	.53[a]	.51[a]	1.12[b]	1.22[b]
Ribeye area, cm²	66.3[a]	75.4[b]	78.0[b]	73.4[ab]
Kidney, pelvic and heart fat, %	2.7[a]	2.8[ab]	3.3[bc]	3.5[c]
Hot carcass wt, kg	260[a]	288[b]	330[c]	328[c]
Cold carcass wt, kg	254[a]	279[b]	324[c]	323[c]
Cooler shrink, %	2.4[b]	3.3[c]	1.7[a]	1.8[a]
Yield grade	2.0[ab]	1.8[a]	2.6[bc]	2.9[c]

[a,b,c]Means within same row with same superscript do not differ (P>.05).

ate, and long- and forage-fed the heaviest (P<.05). Cooler shrinkage was lowest (P<.05) for carcasses from longer fed cattle. Carcasses from short-fed cattle experienced the greatest (P<.05) cooler shrinkage.

Yield grades did not differ (P<.05) between carcasses from grass- and short-fed cattle or between carcasses from forage- and long-fed cattle. Yield grade of carcasses from short-fed cattle tended to be lower than that of carcasses from grass-fed cattle because of larger (P<.05) ribeyes in the short-fed carcasses.

Taste Panel. Palatability responses favored those cattle fed the longest time on feed and the highest plane of nutrition. Taste panel responses to L muscle steaks tended to be higher (more desirable) for all characteristics (table 4) with longer feeding. Steaks from grass-fed beef were less (P<.05) tender than steaks from long- and forage-fed beef. Steaks from short-fed beef were less (P<.05) tender than those from long-fed beef, but were similar to steaks from the forage-fed regime. The observed tenderness differences are likely attributed in part to differences in external fat which affect rate of chill. A decreased rate of temperature decline and a resulting increase in tenderness with increased fat in lamb carcasses have been reported by Smith *et al.* (1976). Other researchers have found similar results with beef carcasses (Wanderstock and Miller, 1948; Reddish, 1956; Smith *et al.*, 1974; Kropf *et al.*, 1975; Bowling *et al.*, 1977). Little or no differences in tenderness due to nutritional regime were observed when cattle were fed to equal fatness (Bull *et al.*, 1941; Hunt *et al.*, 1953) or similar yield grades (Huffman, 1974; Schupp *et al.*, 1976). Bidner (1975) concluded that type of diet has little influence on organoleptic components of beef if cattle are fed to

TABLE 4. TASTE PANEL RESPONSES[d] FOR *LONGISSIMUS* MUSCLE AND EXTERNAL FAT BY NUTRITIONAL REGIME

	Nutritional regime			
	Grass-fed	Short-fed	Long-fed	Forage-fed
Tenderness	4.8[a]	5.3[ab]	6.5[c]	5.9[bc]
Desirability of flavor (lean)	5.9[a]	6.2[a]	6.9[b]	6.9[b]
Desirability of flavor (fat)	5.8[a]	6.5[b]	7.0[c]	6.9[c]
Juiciness	5.8[a]	6.2[a]	6.4[ab]	6.9[b]

[a,b,c]Means within the same row with same superscript are not different (P>.05).

[d]Tenderness, flavor, and juiciness evaluated on 9-point scale (1 = extremely tough, dry or undesirable flavor; 5 = midpoint; 9 = extremely tender, juicy or desirable flavor).

TABLE 5. MEANS FOR SHEAR FORCE BY NUTRITIONAL REGIME

	Nutritional regime			
	Grass-fed	Short-fed	Long-fed	Forage-fed
	Shear force (kg)			
Longissimus	2.9	3.2	3.4	3.2
Semitendinosus	4.1	4.1	3.9	3.9
Biceps femoris	6.2[a]	6.5[ab]	5.8[a]	6.9[b]
Semimembranosus	4.7	4.4	4.3	4.1
Averaged over muscles	4.4	4.5	4.4	4.5

[a,b]Means within the same row with same or no superscript are not different (P>.05).

comparable weights and grades.

Flavor of steaks from long- and forage-fed beef was rated more desirable (P<.05) than that of steaks from grass- and short-fed beef. Higher marbling levels in long- and forage-fed beef likely contributed to this observation. Reddish (1956), Meyer *et al.* (1960), Oltjen *et al.* (1971) and Kropf *et al.* (1975) reported greater tenderness, flavor and overall desirability in higher grading cattle compared with lower grading cattle. Moody (1976) stated that flavor is highly associated with intramuscular fat which is usually found in greater amounts in grain-fed cattle than grass-fed animals.

Flavor of fat became more desirable as feeding period increased (table 4). Flavor desirability of fat from long- and forage-fed beef was superior (P<.05) to that of short-fed which was more desirable (P<.05) than grass-fed beef. This agrees with Meyer *et al.* (1960) and Malphrus (1957) who reported that a taste panel detected flavor differences between steaks with yellow and white fat.

Steaks from forage-fed cattle were juicier (P<.05) than steaks from grass- and short-fed cattle. No difference in juiciness was noted among L muscle steaks from grass-, short- and long-fed beef or between L muscle steaks from long- and silage-fed beef. Moody (1976) reported that higher marbling levels are associated with increased juiciness.

Shear Force. Shear force of L, ST, and SM muscle steaks did not differ among nutritional regimes (table 5). Shear force of BF steaks from grass and long-fed cattle was, however, less than that of steaks from forage-fed cattle. No difference in shear force was noted among steaks from grass-, short- and long-fed beef or between those from short- and forage-fed beef. Even though differences were noted for taste panel tenderness responses among nutritional regimes, generally the mean differences were not large. This may be the reason the same differences were not detected by shear force evaluation. It is also possible that the cores used in shear force analysis with near-parallel (to the long axis of the core) fiber orientation led to discrepancy between tenderness ratings (table 4) and shear force values (table 5) for steaks from the L muscle. Shear force results generally agree with Meyer *et al.* (1960) who found shear force values did not differ between steaks from grain- and forage-fed steers, although those from forage-fed steers tended to be higher. Kropf *et al.* (1975) and Bowling *et al.* (1976) reported that steaks from grain-fed beef had lower shear force values than steaks from grass-fed beef. Huffman (1974) rated steaks from grass finished cattle slightly more tender by Warner-Bratzler shear than those from cattle fed grain 90 days. Grass finished carcasses were slightly fatter and chilled more slowly than grain finished carcasses. Bayne *et al.* (1969) found no difference in tenderness between carcasses from cattle finished on a corn silage as opposed to a high energy corn ration.

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