THE EFFECT OF GRAIN FEEDING ON THE EATING QUALITY OF BEEF FROM CULLED COWS

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The cooking and eating quality characteristics of rib-eye roasts obtained from cows after removal from the breeding herd and after 8 or 16 wk of realimentation were determined. Evaluations of the effects of maturity class (physiological age) and external fatness on meat quality were also made. Cooking losses from roasts were affected by maturity class, external fat ''cover'' and realimentation. The percentage of fat in raw muscle samples representing maturity classes II (intermediate) and III (mature) was similar and significantly higher than that of comparable maturity class I (youthful) samples. There were significant differences in percent fat due to realimentation. Trained panelists determined significant effects of maturity on tenderness, amount of connective tissue and amount of fat. Water-holding capacity data for roasts from maturity classes I and II were similar and significantly higher than comparable samples from maturity class III animals. However, objective measurements of tenderness, softness and color for roasts showed no differences due to maturity class. All palatability traits evaluated subjectively and objectively in roasts show no significant effects of either external fat or realimentation. Thus these studies suggest that rib-eyes obtained from culled cows with or without realimentation may be acceptable to Canadian consumers as a retail cut.

On a évalué les qualités culinaires et gustatives de rôtis de faux-filet provenant de vaches retirées du troupeau d'élevage et soumises à un régime de 8 ou de 16 semaines d'engraissement. Les évaluations ont également porté sur les effets de la classe de maturité (âge physiologique) et de l'épaisseur du gras de couverture. Les pertes à la cuisson variaient selon la classe de maturité, l'épaisseur du gras de couverture et le régime d'engraissement. Les pourcentages de graisse dans des échantillons de muscle cru correspondant aux classes II (intermédiaire) et III (adulte) étaient du même ordre, mais tous deux étaient significativement plus élevés que dans les échantillons de muscle de classe I (jeune). Le régime de finition a donné lieu à des différences significatives dans la proportion de gras. Des dégustateurs d'expérience ont décelé des effets significatifs du degré de maturité sur la tendreté et sur les proportions de tissue conjonctif et de gras. La capacité de rétention de l'eau était la même pour les rôtis de classes I et II, mais elle y était significativement plus forte que pour ceux de classe III. Toutefois, des mesures objectives de la tendreté, de la résistance au pénétromètre et de la couleur des rôtis n'ont pas révélé de différences entre ces classes. Aucun des caractères d'appétibilité, mesurés par voie subjective ou objective, n'a montré d'effets significatifs liés à l'épaisseur du gras de couverture ou au régime d'engraissement. Il semble donc que les rôtis de faux-filet obtenus de vaches de réforme, avec ou sans engraissement préalable, puissent être acceptables au consommateur canadien.

Culled beef cows are normally sold directly off the range in lean body condition and used as a source of manufacturing beef. However, there is evidence that culled cows grow rapidly and efficiently when realimented with suitable feed (Swingle et al. 1979; Graham and

Price 1980) and that this enterprise may be more profitable to the rancher than simply selling the cows for "salvage" value.

Culled cows may vary in age from as little as 2 to greater than 15 yr. Although substantial differences in tenderness of meat from young and mature animals have been reported in earlier studies (Simone et al. 1959; Romans et al. 1965; Walter et al. 1965; Breidenstein et al. 1968), more recent workers (Ramsey et al. 1967; Berry et al. 1974; Dryden et al. 1979) have noted only a slight or non-existent decrease in tenderness after an animal has reached maturity. Determination of maturity class (carcass physiological age) is the basis of meat quality grading in Canada. However, current Canadian information on the relationship between maturity class and the eating quality characteristics of beef is limited.

There is a lack of published information on the effect of short-term feeding on meat palatability. A recent study (Dryden et al. 1979) reported that beef from realimented cows was not consistently more acceptable than beef from non-fed animals.

Thus, the following study was conducted to determine the influence of maturity, fatness and realimentation on the cooking losses and eating quality of a tender cut (rib-eye) obtained from culled cows.

MATERALS AND METHODS

Samples

The beef samples used in this study were obtained from the culled cow feeding experiment described by Graham and Price (1980). A total of 90 cows of mixed breeding, varying in age from about 1 to about 16 yr were used. At culling (February 1979) the cows were allocated randomly within each breed and age cell into three groups. The Group 1 cows were marketed immediately. Group 2 cows were grain-fed for 8 wk prior to slaughter; Group 3 cows were grain-fed for a total of 16 wk and then slaughtered. One of the cows allocated to Group 3 died during the experiment.

The cattle were slaughtered at a commercial packing plant and the carcasses chillled overnight. The following morning they were graded by officers of the Livestock Division of Agriculture Canada. The graders also recorded (Form ML107) the physiological age class (maturity I, II or III) and fat thickness at four positions over the longissimus muscle between the 11th and 12th ribs for each carcass. The left sides were returned to the Meat Laboratory at the Edmonton Research Station.

After 7 days of aging at 1°C, a three-rib roast (9th to 11th ribs inclusive) from each left front quarter was excised. Raw meat samples (about 150 g, free of subcutaneous and intermuscular fat) were removed from the area of the 9th rib of each roast for chemical analysis and objective measurements. Each of the 89 roasts was placed in a polyethylene bag, wrapped in heavy freezer paper, frozen at −32°C and stored at −29°C for up to 2 mo.

Five roasts, representing similar maturity and fatness levels, were randomly selected for each cooking period. In order to insure that length of frozen storage for all roasts was the same and to avoid excessively long frozen storage of the samples, all the roasts representing animals of Group 1 were evaluated before testing those from animals of Group 2. Roasts from animals of Group 3 were evaluated last. Prior to testing, the wrapped roasts were thawed for 5 h at room temperature and then 65 h in a refrigerator at 3°C and weighed (defrosted weight). Roasts were individually cooked in one of five identical household ovens at 163°C to an internal temperature of 61°C, measured with two thermocouples which had been placed in the center of each roast. The thermocouples were connected to a recording potentiometer.

Total cooking time (min) was noted and percentage cooking losses based on the defrosted weights were calculated. The percent fat in the drip of roasts was determined by employing the procedure described by Woolsey and Paul (1969). The cooked roasts were wrapped in plastic wrap (Saran) and refrigerated (3°C) overnight before being sampled (Harries et al. 1963).

Sensory Evaluation

Sampling procedures were standardized: the section of longissimus muscle was removed from the cooked rib roasts, and for sensory evaluation 14 (2/judge) 1.3-cm cubes were cut from the same relative positions in each of the roasts. During each of the taste panel sessions, room temperature samples (two cubes per roast) from each of the five roasts were presented randomly to each of the panelists. The taste panel consisted of seven females and was heterogenous with regard to age, socio-economic status and religion. The panelists had previous experience in judging meat and had been trained for this study over a 2-wk intensive training period. Each judge scored each of the roasts from each treatment once. The cubes of lean meat were scored for softness (force required to compress sample with molar teeth), tenderness (based on the number of chews) and residual connective tissue as described by Hawrysh et al. (1979). In addition, three judges evaluated the fat content of cooked slices from each of the roasts. The amount of fat was scored on a seven-point descriptive scale, with seven indicating no fat.

Objective Measurements

Meat samples for objective measurements were taken from the same relative position in each of the refrigerated cooked roasts, adjacent to those used for sensory evaluation. All objective measurements were made on samples equilibrated to room temperature. Four cores, 1.3 cm in diam, cut parallel to the muscle fibers were taken from each roast. The cores were tested on the Ottawa Texture Measuring System (OTMS) equipped with a Warner Bratzler blade as described by Hawrysh et al. (1979). In addition, three samples from each roast were tested on the OTMS equipped with a Kramer shear compression cell, using the method described by Hawrysh et al. (1979). Shear values were recorded as either total force (kg) or maximum force in kg/g. Penetrometer readings following the procedure of Paul et al. (1970) were obtained on four samples from each roast.

Three samples from each roast were used to determine water-holding capacity in a Carver Press as described by Hawrysh and Berg (1976). Water-holding capacity was calculated according to the method of Miller and Harrison (1965).

Color was determined on duplicate samples from each of the cooked roasts using a Hunter Color Difference Meter. The instrument was standardized using the white standard tile (C2-8692) with values of $L = 92.7$, $a = 1.0$, $b = 0.3$. Color was also determined on one sample from each of the cooked roasts at four wavelengths (485, 545, 625 and 655 nm) with a Bausch and Lomb spectronic 20 Colorimeter with reflectance attachment standardized against $MgCO_3$. A Fisher Accument Model 230 pH/ion meter was used to determine the pH of raw samples as described by Hawrysh and Berg (1976).

All the raw samples were analyzed for percentage of moisture and fat (ether extract) (Association of Official Agricultural Chemists (AOAC) 1965).

Statistical Evaluation

Carcasses were classified according to maturity class (I, II, or III) and fat depth (0.00–0.13, 0.25, 0.51, 0.77 or 1.01+ cm). For each of the three testing sessions of roasts representing a Group, roasts, one from each carcass, were cooked in one of five ovens on 1 of 6 days. Because of the unequal observations per fatness by maturity cell, no orthogonal allocation of roasts to day of cooking and oven was possible. However, whenever possible, roasts of differing maturity were allocated within days of cooking.

Data were analyzed using least squares analyses of variance for unequal numbers (Mehlenbacher 1978). For ease of computation, taste panelist data were summarized across panelist and objective measurements were summarized across observation. Sources of variation were: maturity class ($n = 3$), fat depth ($n = 5$), realimentation ($n = 3$) and fatness by maturity, fatness by feeding and maturity by feeding interactions. Since previous experimental work (Hawrysh and Berg 1976; Hawrysh et al. 1979) in this laboratory has shown no significant effects of day and oven, they (these trails) were not included as sources of variation. Newman-Keuls' (Steel and Torrie 1960) multiple range test was used to establish significant differences among treatments.

RESULTS

The slaughter and carcass data for these cattle have been described (Graham and Price 1980).

Maturity

Raw weight differed significantly among roasts from the three maturity classes (Table 1). There was a trend toward increased cooking time for roasts with increase in maturity (and weight), but the differences were not significant. With the exception of the lack of difference between maturity classes II and III for volatile cooking losses, all cooking losses increased significantly with increasing physiological age. In addition, the percentage of fat in raw muscle samples obtained from intermediate and mature animals was similar and significantly higher than that of comparable samples obtained from youthful animals. However, percentages of moisture in all samples were similar.

Taste panel scores (Table 2) show that there were significant differences in tenderness, amount of residual connective tissue and amount of fat due to maturity. Although there was a trend toward decreased tenderness with increasing age, data for objective measurements of roasts for each maturity class indicate that samples were similar in softness (penetrometer), tenderness (OTMS) and color. However, water-holding capacity data show that roasts from the youthful and intermediate maturity classes were similar and higher in juiciness than comparable samples from mature animals.

Fatness

The raw weights of roasts (Table 3) representing the two highest fat levels (IV and V) were similar and significantly greater than those of roasts from animals with lower fat levels which were also similar. Although cooking time for roasts obtained from fatter (and heavier) animals (IV and V fatness levels) tended to be greater than that of roasts from leaner animals (fatness levels of III and lower), the differences were not significant. Percentage total losses of roasts from animals of the two highest fat levels were significantly greater than those from animals with lower fat levels. Differences in the volatile losses were not statistically significant. Percent drip losses were similar for roasts taken from animals with the two highest fat levels, but differed significantly for all other fat levels. Roasts representing fatness level V had more ($P < 0.05$) percent fat in drip than roasts from either fatness level I or II. Although the differences were not statistically significant, the percent fat in the raw samples was lowest for roasts from animals with the least fat depth and highest for the 1.01 cm and greater fatness level. Percentages of moisture were similar and highest for the 0.00 to 0.13- and 0.51-cm fatness levels, but differed significantly for all other fat levels.

Average values for palatability characteristics for roasts (Table 4) indicate that the samples from animals representing all fatness levels were similar. Data for objective measurements on roasts support sensory evaluations which showed no effect due to fatness.

Table 1. Treatment means and standard errors for raw weight, cooking time, cooking losses and chemical data for rib-eye roasts from carcasses of three maturity classes

Characteristic	Maturity class I (youthful)	Maturity class II (intermediate)	Maturity class III (mature)	SE range
Number of cows	56	15	18	
Age at slaughter (days)	829.9*a*	1519.1*b*	3292.7*c*	31.00–296.54**
Hot carcass weight (kg)	237.8*a*	296.5*b*	296.2*b*	6.61– 18.49**
Fat thickness (11/12 rib) (cm)	0.53	0.57	0.83	5.94– 13.59
Raw weight of roast (g)	3150.37*c*	3524.14*b*	3930.69*a*	72.47–144.61***
Total cooking time (min)	139.98	152.23	147.28	2.93– 5.85
% cooking losses				
Total	19.09*c*	22.11*b*	23.69*a*	0.26– 0.51***
Volatile	14.48*b*	15.38*a*	15.71*a*	0.18– 0.36***
Drip	4.61*c*	6.72*b*	7.98*a*	0.15– 0.30**
% fat in drip	67.11	65.28	70.88	1.26– 2.51
Chemical data				
%fat (raw samples)	2.36*b*	2.98*a*	2.79*a*	0.11– 0.23**
% moisture (raw samples)	74.45	74.18	74.14	0.12– 0.24
pH (raw samples)	5.65	5.71	5.71	0.02– 0.04

a–c Means within the same row sharing a common letter are not significantly different at $P < 0.05$.
**, ***Significant at $P < 0.01$, and $P < 0.001$, respectively.

Table 2. Treatment means and standard errors for palatability scores for rib-eye roasts from carcasses of three maturity classes

Type of data	Maturity class I (youthful)	II (intermediate)	III (mature)	SE range
Subjective†				
Softness	4.8	4.7	4.2	0.12–0.25
Tenderness	5.0*a*	4.6*b*	4.3*c*	0.12–0.24*
Residual connective tissue	6.4*a*	5.8*b*	5.3*c*	0.10–0.20***
Amount of fat	5.3*a*	4.8*b*	4.5*c*	0.14–0.29*
Objective				
Water-holding capacity	0.67*a*	0.66*a*	0.62*b*	0.01–0.01*
OTMS - Warner Bratzler blade (kg)	0.16	0.16	0.18	0.00–0.01
OTMS (kg)	2.83	2.99	3.06	0.08–0.16
OTMS (kg/g)	0.19	0.19	0.20	0.00–0.01
Penetrometer (mm)	90.36	88.18	84.64	1.52–3.04
Color‡				
L	46.46	47.27	45.28	0.36–0.72
a	4.59	4.77	4.69	0.18–0.35
b	10.36	10.63	10.34	0.08–0.16
Color - Spec 20 (545 nm)	20.75	20.96	20.08	0.41–0.81

a–c Means within the same row sharing a common letter are not significantly different at $P < 0.05$.
*, ***Significant at $P < 0.05$ and $P < 0.001$, respectively.
†For a description, see text.

Realimentation

The raw weight of roasts (Table 5) obtained from animals grain-fed for 0 and 8 wk was similar and significantly lighter than that of comparable roasts obtained from animals grain-fed for 16 wk. Differences in the total cooking time for roasts were not statistically significant, but the mean for roasts from animals grain-fed for 16 wk was the highest. The percentage total cooking losses from roasts from all realimentation treatments were similar. However, the volatile losses of roasts from animals grain-fed for 0 to 8 wk were similar and significantly greater than those from animals grain-fed for 16 wk. In addition, there were significant differences in percentage drip loss, percent fat in the drip, and chemical data for percent fat and percent moisture in raw samples due to realimentation.

Subjective data of trained panelists (Table 6) and data for objective measurements showed no significant effects of grain-feeding on the eating quality of roasts. However, as the length of grain-feeding increased, there was a tendency for the softness and tenderness of roasts to improve.

Analysis of variance showed no significant interactions between maturity and fatness, or fatness and feeding. However, significant interactions between maturity and feeding were determined for three (percentage volatile, drip and total cooking losses) of the many quality characteristics studied. The maturity by feeding interaction was variable for percent total cooking losses. For each maturity level, as the length of feeding increased, percentage volatile losses tended to increase and percent drip losses tended to decrease.

DISCUSSION

Maturity

Marked differences in maturity class were achieved by the design in this study. Graham and Price (1980) reported that subcutaneous fat depth was greatest in the maturity III carcasses and least in maturity I. Chemically determined intramuscular fat at the ninth rib

Table 3. Treatment means and standard errors for raw weight, cooking time, cooking losses and chemical data for rib-eye roasts from carcasses of five different external fat levels

	Fat depth (cm)					
	I	II	III	IV	V	
Characteristic	0.00 - 0.13	0.25	0.51	0.77	≥ 1.01	SE range
Number of cows	20	16	16	16	18	
Age at slaughter (days)	1065.3	1357.1	1494.3	1553.2	1792.8	111.76–343.98
Hot carcass weight (kg)	221.3*a*	234.6*a*	247.9*a*	285.6*b*	313.2*b*	7.46– 15.51**
Raw weight of roast (g)	2996.35*b*	3151.50*b*	3353.02*b*	4163.54*a*	4010.93*a*	159.73–305.21***
Total cooking time (min)	124.06	148.71	142.75	155.52	161.45	6.46– 12.35
% cooking losses						
Total	19.99*b*	20.94*b*	20.94*b*	23.53*a*	22.75*a*	0.56– 1.08**
Volatile	16.46	15.03	14.38	15.46	14.62	0.39– 0.75
Drip	3.54*d*	5.90*c*	6.56*b*	8.07*a*	8.13*a*	0.34– 0.64**
% fat in drip	44.45*c*	69.08*b*	73.28*ab*	73.94*ab*	78.04*a*	2.77– 5.30**
Chemical data						
% fat (raw samples)	1.87	2.85	2.42	2.84	3.57	0.25– 0.48
% moisture (raw samples)	75.00*a*	74.40*b*	74.81*a*	73.75*c*	73.34*d*	0.27– 0.52*
pH (raw samples)	5.69	5.61	5.76	5.68	5.68	0.04– 0.08

a – *c* Means within the same row sharing a common letter are not significantly different at $P < 0.05$.
*, **, ***Significant at $P < 0.05$, $P < 0.01$ and $P < 0.001$, respectively.

Table 4. Treatment and standard errors for palatability scores for rib-eye roasts from carcasses of five different external fat levels

	Fat depth (cm)					
Type of data	I 0.00 - 0.13	II 0.25	III 0.51	IV 0.77	V ≥ 1.01	SE range
Subjective						
Softness	4.7	5.0	4.4	4.1	4.8	0.28–0.52
Tenderness	4.7	5.1	4.3	4.5	4.8	0.26–0.50
Residual connective tissue	6.3	6.0	5.6	5.5	5.7	0.22–0.42
Amount of fat	5.6	4.6	5.0	4.5	4.6	0.32–0.61
Objective						
Water-holding capacity	0.66	0.64	0.64	0.67	0.64	0.02–0.03
OTMS - Warner Bratzler blade (kg)	0.18	0.16	0.19	0.16	0.14	0.01–0.02
OTMS (kg)	2.83	2.81	3.16	3.06	2.93	0.18–0.35
OTMS (kg/g)	0.18	0.19	0.21	0.20	0.20	0.01–0.02
Penetrometer	90.36	92.97	83.30	83.48	88.52	3.35–6.41
Color†						
L	46.89	45.27	46.41	45.71	47.41	0.80–1.52
a	3.52	5.03	5.48	4.73	4.66	0.39–0.74
b	10.41	10.55	10.44	10.22	10.60	0.18–0.34
Color - Spec 20 (545 nm)	19.18	20.93	20.09	21.83	20.94	0.89–1.71

†For a description, see text.

Table 5. Treatment means and standard errors for raw weight, cooking time, cooking losses and chemical data for rib-eye roasts from carcasses obtained from animals grain-fed varying lengths of time

Characteristic	Realimentation 0 wk	8 wk	16 wk	SE range
Number of cows	30	30	29	
Age at slaughter (days)	1330.4*a*	1493.9*a*	1510.4*a*	185.20–232.92
Hot carcass weight (kg)	217.2*a*	249.5*b*	313.5*c*	5.79– 10.99**
Fat thickness (cm)	0.19*a*	0.62*b*	1.00*c*	2.77– 9.26**
Raw weight of roasts (g)	3369.76*b*	3273.54*b*	3961.90*a*	136.22–194.74***
Total cooking time (min)	142.38	142.49	154.62	5.51– 7.88
% cooking losses				
Total	21.57	21.76	21.56	0.48– 0.69
Volatile	16.27*a*	15.80*a*	13.50*b*	0.33– 0.48***
Drip	5.29*c*	5.96*b*	8.06*a*	0.29– 0.41**
% fat in drip	59.10*c*	65.92*b*	78.26*a*	2.36– 3.38**
Chemical data				
% fat (raw samples)	1.80*c*	2.41*b*	3.92*a*	0.21– 0.30**
% moisture (raw samples)	75.25*a*	74.49*b*	73.04*c*	0.23– 0.33**
pH (raw samples)	5.68	5.73	5.66	0.04– 0.05

a–c Means within the same row sharing a common letter are not significantly different at $P < 0.05$.
**, ***Significant at $P < 0.01$ and $P < 0.001$, respectively.

did not follow this pattern precisely, although the two older classes were significantly fatter than the maturity I class (Table 1). Other workers (Tuma et al. 1963; Norris et al. 1971) have reported significant increases in extractable intramuscular lipid with increases in animal age. However, Schake and Riggs (1973), Dryden et al. (1979) and Thomassen et al. (1979) found no differences in percent fat attributable to animal age.

Level of maturity exerted significant effects on the eating quality of rib roasts (on tenderness, residual connective rissue and amount of fat) as determined by trained panelists. In a recent study, Thomassen et al. (1979) found that maturity class I beef was significantly more tender than maturity class II beef. Tuma et al. (1963) noted that panel tenderness scores decreased with advancing age. However, Norris et al. (1971) and Reagan et al. (1976) have reported that panel scores for tenderness were not significantly affected by level of maturity.

Water-holding capacity data for roasts representing maturity classes I and II were higher than that of maturity class III roasts. The lower water-holding capacity values for maturity class III samples probably reflect the increase in percent fat present in these samples.

The data for softness of roasts determined from objective measurements (penetrometer) support trained panel evaluations which showed no differences in softness attributable to maturity. However, the data for samples tested on the OTMS equipped with either the Warner Bratzler blade or the Kramer shear compression cell did not support taste panel evaluations of tenderness. Other workers (Woodhams and Trower 1965; Price 1971) have reported similar low relationships between objective measurements and sensory evaluations. Tuma et al. (1963) found that correlation coefficients for taste panel scores and Warner Bratzler shear values were more closely related for 6- and 18-mo-old cattle than for those 42 and 90 mo old. Dryden et al. (1979) reported that shear force values for longissimus muscles from cull cows 3 and 10 yr of age were more tender than from 6-yr-old cull cows. However, Thomassen et al. (1979) noted that shear force values corresponded with sensory judgments of tenderness which indicated that maturity class I steaks were more tender than maturity class II steaks.

Maturity exerted a significant effect on percent cooking losses determined by this study. The percent total and drip losses of roasts show significant differences due to age; percentage volatile losses of roasts from maturity class I were lower than those of comparable roasts from older animals. In contrast, Thomassen et al. (1979) found no significant differences in percent cooking loss attributable to maturity class. In the present study, differences in cooking losses of roasts (due to maturity) may also be a function of differences in weight and fat content of the roasts.

Fatness

In this experiment carcasses were classified into five levels based on subcutaneous fat depth between the eleventh and twelfth ribs. Although percent fat tended to increase with increases in fat class, level of fat did not significantly influence chemically determined fat or subjective evaluations of the amount of fat in cooked roasts. Factors influencing the distribution of fat among depots within the carcass are poorly understood particularly under conditions of realimentation (Butterfield 1966).

No differences in subjective and objective measures of tenderness attributable to level of fatness were detected in the present experiment. Recently, Jennings et al. (1978) reported that non-significant differences in shear force occurred between modest and slight marbling categories for steaks from carcasses with 1.02 cm or less amounts of external fat. Other workers (Goll et al. 1965; Romans et al. 1965; Breidenstein et al. 1968; Norris et al. 1971) have found that panel tenderness score and shear force values were not statistically affected by measures of fat content.

Percent total cooking losses of roasts from the higher fat levels were similar and significantly different from roasts of the lower fatness levels. Statistically significant effects were found for increasing drip losses

Table 6. Treatment means and standard errors for palatability scores for rib-eye roasts from carcasses obtained from animals grain-fed varying lengths of time

	Realimentation			
Type of data	0 wk	8 wk	16 wk	SE range
Subjective				
Softness	4.3	4.7	4.9	0.23–0.34
Tenderness	4.1	4.8	5.1	0.22–0.32
Residual connective tissue	5.4	5.9	6.2	0.19–0.27
Amount of fat	5.6	4.6	4.4	0.27–0.39
Objective				
Water-holding capacity	0.68	0.63	0.64	0.01–0.02
OTMS – Warner Bratzler blade (kg)	0.18	0.17	0.16	0.01–0.02
OTMS (kg)	3.22	2.96	2.70	0.16–0.22
OTMS (kg/g)	0.21	0.19	0.18	0.01–0.01
Penetrometer (mm)	93.74	86.70	82.74	2.86–4.09
Color†				
L	46.29	46.60	46.13	0.68–0.97
a	5.59	4.18	4.28	0.33–0.47
b	10.74	10.26	10.34	0.15–0.21
Color – Spec 20 (545 nm)	21.48	20.66	19.65	0.76–1.09

†For a description, see text.

and percent fat in the drip from roasts of the higher fatness levels. Goll et al. (1965) found that marbling exerted a significant effect on percent drip and percent total losses.

Realimentation

Length of realimentation exerted a significant effect on the chemical composition of the meat. The findings for percent fat agreed with fat depth and marbling data for the same carcasses which showed a linear relationship between length of grain feeding and carcass fatness (Graham and Price 1980).

In spite of fat differences in the roasts, the data (Table 6) indicate that realimentation for up to 16 wk did not significantly affect the eating quality of the roasts. Dryden et al. (1979) reported that a realimentation of up to 108 days had no effect on the tenderness of longissimus muscles from cow carcasses. In an earlier study of longissimus roasts of carcasses from regular steers and long-fed young cows (205 days on high energy feed) Hawrysh et al. (1975) found no significant differences in the tenderness of roasts determined subjectively and objectively.

In this study, length of realimentation did not influence percent total cooking losses. However, the volatile losses of roasts obtained from non-fed animals and from animals grain-fed for 8 wk were higher and differed significantly from those of roasts from animals grain-fed for 16 wk. Statistically significant increases were found in drip losses and percent fat in drip of roasts from grain-fed animals. The larger amount of intramuscular fat (Table 5) in roasts from grain-fed animals may account for these findings. Hawrysh et al. (1975) reported that the presence of intramuscular fat in longissimus roasts from mature long-fed cows increased drip loss. Goll et al. (1965) found that cooking losses were generally greater for steaks with more marbling. In contrast, Jacobson and Fenton (1956) reported that cooking losses attributable to level of nutrition were negliglble.

Thus some differences in the quality characteristics of roasts due to maturity have been noted. Although meat from maturity class II and III cull cows was less desirable (in tenderness and softness) than meat from maturity class I cows, the differences were small. Thus it would appear that tender beef cuts from culled cows are likely to be acceptable to some consumers. For practical purposes, the results obtained from subjective and objective measurements indicate that the influence of external fat on the palatability of meat obtained from culled cows is negligible. Beef from the various fat categories was comparable and judged to be slightly tough to tender. Comparisons of the eating quality characteristics of longissimus roasts from culled cows with or without realimentation show that meat from all animals was similar in palatability. Thus, these findings indicate that tender cuts from fed or unfed culled cows may be removed and sold as a cheaper source of quality beef for the supermarket trade. Dryden et al. (1979) have also indicated that the loin from culled cows may be removed and sold as a retail cut rather than used as ground beef items, regardless of whether or not the animals have been realimented.

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