EFFECT OF MATURITY AND MARBLING LEVEL OF THE BEEF CARCASS ON HISTOLOGICAL CHARACTERISTICS, TENDERNESS AND JUICINESS OF LONGISSIMUS DORSI

by 544

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INTRODUCTION

United States Department of Agriculture (U.S.D.A.) beef graders place great emphasis on maturity and marbling of beef carcasses. Research has shown a lack of consistency between those factors and quality of beef (Blumer, 1963). Changes in feeding management and animal breeding have become increasingly important to characteristics associated with the quality of beef, which also may point to overemphasis of maturity and marbling (Lawrie, 1966).

In 1965 the number of marbling levels in the U.S.D.A. standards for grading beef were reduced and less emphasis was placed on maturity in the Prime, Choice, Good, and Standard Grades (U.S.D.A., 1965). Most studies found in the literature relative to the relationship of maturity and marbling of the carcass to the palatability of beef based maturity of the carcass on the chronological age of the animal, and use the longissimus dorsi (LD) muscle. Information is needed on the effect of maturity and marbling when maturity is based on the size, shape, and ossification of the bones and cartilages and the color and texture of the lean flesh as described in U.S.D.A. standards (U.S.D.A., 1965). The Departments of Animal Husbandry and Foods and Nutrition at Kansas State University initiated extensive work to obtain such information.

This study included only the investigation of histological characteristics, tenderness (panel scores and Warner-Bratzler shear values), juiciness, flavor and over-all acceptability of the LD muscle located at the 11th thoracic vertebra.

Relationships of tenderness, juiciness, and over-all acceptability to histological characteristics were studied.

REVIEW OF LITERATURE

Effect of Maturity on Selected Characteristics Related to the Palatability of Beef

Although the U.S.D.A. grading standards place much emphasis upon maturity, Ritchey and Hostetler (1964) reported that in animals ranging from 32 to 62 weeks of age only isolated data pointed toward any influence of age on eating quality and those cases were attributed to animal variation. It appeared to Goll et al. (1965) that wide extremes in carcass maturity influenced the eating quality of beef more than wide extremes in marbling. Several factors should be considered in a statement concerning the importance of maturity to the quality characteristics of beef.

Fiber diameter. Several workers found that fiber diameter increased with increase in animal age to maturity. Gillis and Henrickson (1967) reported that the increase in size was rapid while the animal was young and leveled off as the animal approached maturity. Hiner et al. (1953) stated that the greatest change in fiber width occurred between 8 and 14 months of age. Tuma et al. (1962b) noted a gradual increase in fiber diameter of the LD muscle with increasing age of 6 to 90 months old. Muscle fiber width of commercial grade cows was slightly larger than that for corresponding tissue from younger animals (Doty and Pierce, 1961). They also noted that within the Prime grade, fiber diameter was larger in heavy weight than in light weight carcasses; and that fiber diameter was larger in samples obtained in October than in August and smallest in June samples irrespective of age for the groups studied. Romans et al. (1965) studied the diameter of fibers in muscle from carcasses in several maturity levels (Fig. 1). Fiber diameters were significantly ($P < 0.05$) larger in muscle from carcasses in C and D levels than in muscle from carcasses in the B level. Diameters of fibers in muscle at the B, C, and D levels did not differ significantly from those at the A level of maturity. Swanson et al. (1965) observed large and significant ($P < 0.01$) differences in LD fiber size among animals of the same weight and grade.

There has been question about the true relationship between fiber width and tenderness of beef. Hiner et al. (1953) indicated that tenderness and fiber width in mature animals were more closely associated ($r = 0.77$) than in the younger immature carcasses ($r = 0.50$), and as fiber width increased, resistance to shearing increased. Within age groups there seemed to be little relationship between fiber width and tenderness in the animals 6 to 90 months of age studied by Tuma et al. (1962b). They concluded that the effect fiber diameter may have on tenderness appeared to be attributable to the animal-age-fiber-diameter interrelationships. Gillis and Henrickson (1967) pointed out that the amount of fat, the amount of connective tissue, and the fiber size per unit area all probably affect tenderness.

Explanation of Fig. 1

The physical evidence of maturity is noted by characteristics of the bones. Ossification of cartilages at the end of vertebrae at the junction point of each maturity group is of concern. Those characteristics are used in grade determinations.

PRIME AND CHOICE GRADES

A-	Sacral	- Show distinct deparation.
	Lumbar	- Show no ossification.
	Thoracic	- Show no ossification.
A/B	Sacral	- Are completely fused.
	Lumbar	- Are nearly completely ossified.
	Thoracic	- Show some evidence of ossification.
B/B+	Sacral	- Are completely fused.
	Lumbar	- Are completely ossified.
	Thoracic	- Are partially ossified.

GOOD, STANDARD, AND UTILITY GRADES

A- Same as for Prime and Choice grades.

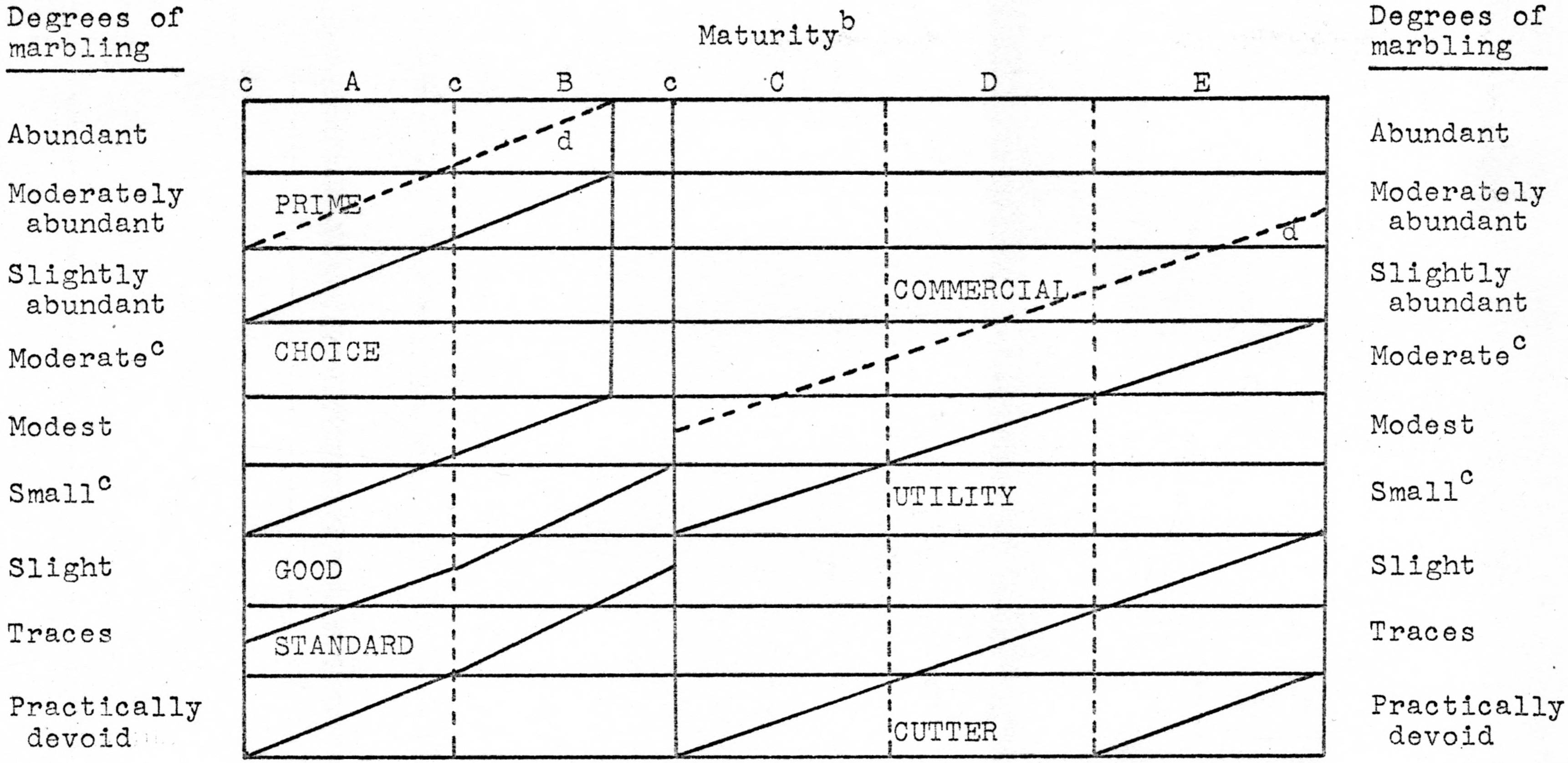
A/B Same as for Prime and Choice grades.

B/C	Sacral	- Are completely fused.
	Lumbar	- Are completely ossified.
	Thoracic	- Are moderately ossified.

COMMERCIAL, UTILITY, ETC. GRADES

C/D	Sacral	- Are completely fused.
	Lumbar	- Are completely ossified.
	Thoracic	- Show considerable ossification outlines are still plainly visible.
D/E	Sacral	- Are completely fused.
	Lumbar	- Are completely ossified.
	Thoracic	- Are ossified and outlines are barely visible.

RELATIONSHIP BETWEEN MARBLING, MATURITY, AND QUALITY[a]



[a]U.S.D.A. 1965. Official United States Standards for Grades of Carcass Beef. Service and Regulatory Announcements. C & MS 99, United States Dept. of Agr., Washington, D. C.

[b]Maturity increases from left to right (A through E).

[c]Level of maturity or marbling used in present study.

[d]Represents midpoint of Prime and Commercial grades.

Fig. 1. Relationship of marbling and maturity for quality determination.

Tenderness. Studies that reported the relationship between tenderness and beef maturity did not concur. Several workers found a decrease in tenderness with increasing maturity (Goll et al., 1965; Walter et al., 1965; Webb et al., 1964; and Tuma et al., 1962a). Tuma et al. (1962a) observed the greatest difference between 18- and 42-month-old animals. Tuma et al. (1963) stated that aging of the carcass affected this relationship. They indicated that 6-month-old calves were less tender (panel scores and shear force values) at two days post-mortem than 18-month-old calves; however, upon aging 14 days, six-month-old calves were more tender. Henrickson and Moore (1965) found that Warner-Bratzler shear values indicated that carcasses from 18-month-old animals were more tender than carcasses from 6-, 42-, or 90-month-old animals. Panel tenderness scores decreased as animal age increased with the greatest decrease in tenderness scores between 18 and 42 months of age.

Some workers reported no significant relationship between tenderness and maturity level (Lowe and Kastelic, 1961; McBee and Wiles, 1967; Ritchey and Hostetler, 1964; and Romans et al., 1965). However, Romans et al. (1965) reported a trend for more mature animals to have higher shear values than less mature animals.

Field et al. (1966) found that when marbling was held constant age had no significant effect on shear values or tenderness. When marbling was not held constant, however, the age of heifers and steers was positively correlated with tenderness scores and Warner-Bratzler shear values.

Quantity of fat. McBee and Wiles (1967) found that B maturity level animals (19 to 30 months of age) generally had higher ($P < 0.01$) ether extract scores on a moisture free basis (MFB) than A maturity level animals (8 to 19 months of age), although within degrees of marbling this relationship was more characteristic of carcasses with lower marbling, and in most cases, differences between maturity groups A and B was not large.

Juiciness. Most workers agreed that juiciness was not affected by maturity level (Goll *et al.*, 1965; Henrickson and Moore, 1965; Lowe and Kastelic, 1961; Ritchey and Hostetler, 1964; Romans *et al.*, 1965; and Tuma *et al.*, 1963). McBee and Wiles (1967) reported steaks from B maturity level carcasses (animals 19 to 30 months of age) (Fig. 1, p. 5) were juicier ($P < 0.01$) than A maturity level carcasses (animals 8 to 19 months of age). Ho and Ritchey (1967) reported that internal cooking temperature influenced the effect of maturity on juiciness. Juiciness decreased as animal age increased from three months to two years when cooked to an internal temperature of 80°C, but not when cooked to an internal temperature of 60°C.

Flavor. Researchers did not report a high relationship between flavor and maturity level. Tuma *et al.* (1963) found that animal age only slightly influenced flavor scores. Generally, the flavor of younger animals was preferred in the study by Romans *et al.* (1965), although significant differences were not found among the ages studied. McBee and Wiles (1967) reported that the flavor of B maturity level steaks (animals 19 to 30 months) were probably more flavorful ($P < 0.10$) than A maturity level steaks (animals 8 to 19 months).

Over-all acceptability. Few researchers reported the over-all acceptability of beef in relation to maturity level. Field *et al*. (1966) indicated that older steers and heifers were more palatable than younger steers and heifers. Ho and Ritchey (1967) found that age had little total effect on the eating quality of beef.

Effect of Marbling on Selected Characteristics Related to the Palatability of Beef

The quantity of visible fat dispersed within the lean portion of muscle (marbling) is used by the U.S.D.A. as a quality indication in the grading standards. Research has indicated a wide variation in marbling levels within one carcass. Cook *et al*. (1964) reported highly significant differences in the quantity and distribution of fat within the LD muscle. The extremeties contained a higher level than the medial portion, and the most uniform distribution was within the 10th to 13th thoracic region. Doty and Pierce (1961) found that the posterior portion of the ribeye contained less intramuscular and linear fat and was not as well marbled as the anterior portion. In another study marbling differed between adjacent steaks (Gilpin *et al*., 1965). It was concluded that the variation of marbling within a muscle, coupled with its poor association with intramuscular fat, as measured by ether extract (MFB) values, indicated that marbling may be inadequate as an index of carcass quality.

Quantity of fat. Several studies were reported that showed a high and significant correlation between ether extract (MFB) and subjective marbling scores (Kropf and Graf, 1959; McBee and Wiles, 1967; Moody, 1967; Romans *et al*., 1965; Walter *et al*., 1965; and Wellington and Stouffer, 1959). Walter *et al*. (1965) reported that nearly 85% of the variation in ether extract could be accounted for by marbling. Marbling level was related to water content and fat (Romans *et al*., 1965), higher levels of marbling exhibited more fat and less moisture content.

Histologically estimated fat content of the LD muscle increased as marbling advanced (Moody, 1967), and compared well with ether extract scores although histological estimates gave higher values.

Juiciness. Juiciness has been referred to as the liquid detectable during the chewing of a bite of meat (Blumer, 1963). Reports conflicted concerning the relationship of juiciness to the amount of marbling in a piece of meat. Goll *et al*. (1965) found that juiciness was not affected by marbling level. Others observed a slight relationship. In a review of the relationship of marbling to palatability, Blumer (1963) reported juiciness was approximately 16% attributable to fat content, whereas Gilpin *et al*. (1965) stated that about one-fifth of the variation in juiciness scores was associated with percentage of fat. They reported that highly marbled carcasses scored only slightly more juicy than low marbled carcasses. A low, but significant correlation coefficient ($r = 0.188^{*}$) was reported by Wellington and Stouffer (1959) between marbling score and panel juiciness scores. Other researchers showed a direct relationship between those two factors. Doty and Pierce (1961) stated that juiciness of broiled steaks was associated closely with fat content as evaluated either by intramuscular fat or marbling rating up to a peak of seven or eight percent intramuscular fat. A direct, linear relationship between the two factors was found by McBee and Wiles (1967). Steaks from moderately marbled groups were rated juicier by Romans et al. (1965) than those from slightly marbled carcasses. Wang et al. (1954) concluded that the total amount of fat in a muscle was related closely to juiciness.

Tenderness. Wang et al. (1954) concluded that the manner in which the fat was distributed throughout the muscle affected tenderness. This function of fat distribution was represented by the amount of surface contact between fat cells and muscle protein (either actomyosin or collagen). It was shown consistently that the tenderness scores of a cooked sample correlated well with the linear fat content of the raw meat. They conceived that the beneficial effect of marbling may be explained on this basis.

Other researchers reported a close relationship between marbling score and tenderness (Doty and Pierce, 1961; and McBee and Wiles, 1967). In a review of the effect of marbling on palatability of meat, Blumer (1963) concluded that a range of values of 0.01 to 36% of the variance in tenderness could be attributed to marbling. Prorated according to the number of samples in all the studies reported this value would be about five percent.

Some workers reported a slight relationship between marbling and tenderness. Gilpin et al. (1965), found that steaks from highly marbled carcasses scored only slightly more tender than steaks from carcasses of low marbling levels. Other workers reported a relationship between marbling and another factor contributing to the production of tenderness. Goll et al. (1965) found that a fine texture and an even distribution of marbling was associated with tenderness, although this was not a predictive value. As external and internal finish increased and as lean became firmer, tenderness of lean increased (Kropf and Graf, 1959). Field et al. (1966) indicated that when age was held constant, meat with high marbling scores was generally tender. Tuma et al. (1962a), on the other hand, noted that the association between marbling and tenderness varied with animal age. Marbling level did not affect tenderness of steaks from 18-month-old animals, whereas more tender steaks from the 42- and 90-month-old animals were found among higher marbling levels.

Still other reports indicated an extremely low and nonsignificant relationship between tenderness and marbling score (Romans et al., 1965; Walter et al., 1965; and Wellington and Stouffer, 1959).

Flavor and over-all acceptability. A lack of significant organoleptic differences, except for juiciness, among marbling levels suggested to Romans et al. (1965) that the effect of marbling on palatability may be overemphasized. Other workers indicated a greater relationship between marbling and palatability of beef. Henrickson and Moore (1965) reported that a high fat level was favored by the organoleptic panel for 18- and 42-month-old animals, whereas low fat levels were preferred for 6- and 90-month-old animals. Simone et al. (1958) found that when greatest differences in marbling occurred, a panel consistently and significantly assigned the more desirable levels of quality, especially for flavor, to the meat from those carcasses showing the most marbling. Field et al. (1966) also found that roasts with moderate marbling levels were significantly ($P < 0.05$) more flavorful than roasts with slight or a trace of marbling. On the other hand, Romans et al. (1965) found that no significant flavor differences existed among levels of marbling.

Effect of Carcass Grade on the Palatability of Beef

The effect of the over-all carcass grade, as measured by the U.S.D.A. grading standards, on palatability of beef has been studied by several workers. Doty and Pierce (1961) reported that Prime carcasses yielded muscle with lower shear strength, more marbling, brighter lean color, more drip loss, but less evaporation, better lean flavor and more tenderness than muscle from carcasses graded Good or Commercial. Except for tenderness scores, Commercial grade cows received mean evaluation scores that fell between Prime and Good. In most instances, the Commercial grade meat was less tender than Prime or Good grade meat. Panel tenderness scores reported by Webb _et al_. (1964) failed to show significant differences between U. S. Choice and Cutter grade carcasses. However, Warner-Bratzler shear values indicated that the Choice grade carcasses were significantly ($P < 0.05$) more tender than the Cutter grade carcasses. McBee and Wiles (1967) found a highly significant difference in sensory tenderness, juiciness, flavor, and shear force values among carcass grades of Prime, Choice, Good, and Standard, with Prime grade being most desirable and Standard least desirable. However, there was considerable variation within grades. Lowe and Kastelic (1961) concluded that although it was widely accepted that the fat content, carcass grade, and age of animal were highly correlated with the palatability of beef, their data indicated that tenderness, juiciness, flavor, and fat content varied within wide limits for carcasses of the same age and grade.

EXPERIMENTAL METHOD

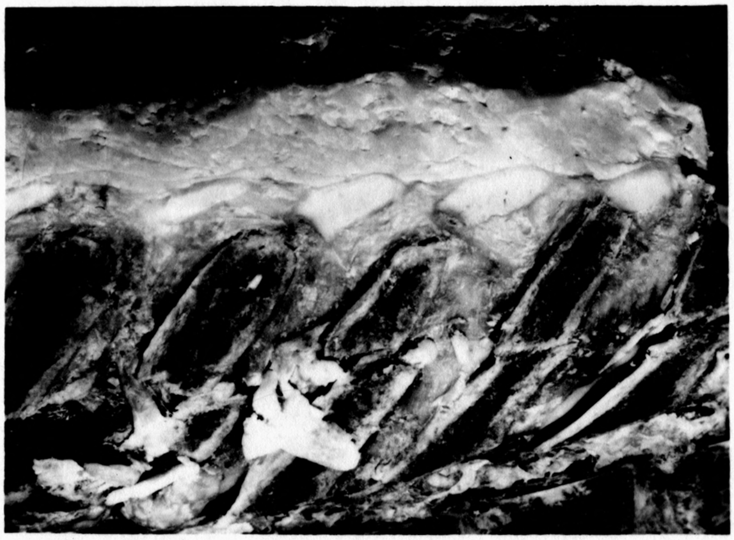
Rib steaks (120, 2-in. thick) cut from the area of the 11th thoracic vertebra from the left and right sides of 60 carcasses represented three levels of maturity (youthful, intermediate, and mature) and two levels of marbling (small and moderate, Fig. 1) at each level of maturity (Figs. 2 and 3). In an attempt to obtain uniform characteristics of maturity (muscle and bone) and marbling, two animal scientists from the Department of Animal

Fig. 2. Maturity levels used as determined by ossification of bones and cartilage in the thoracic region.

1. Youthful, shows no ossification

2. Intermediate, shows some evidence of ossification

3. Approaching maturity, shows partial ossification



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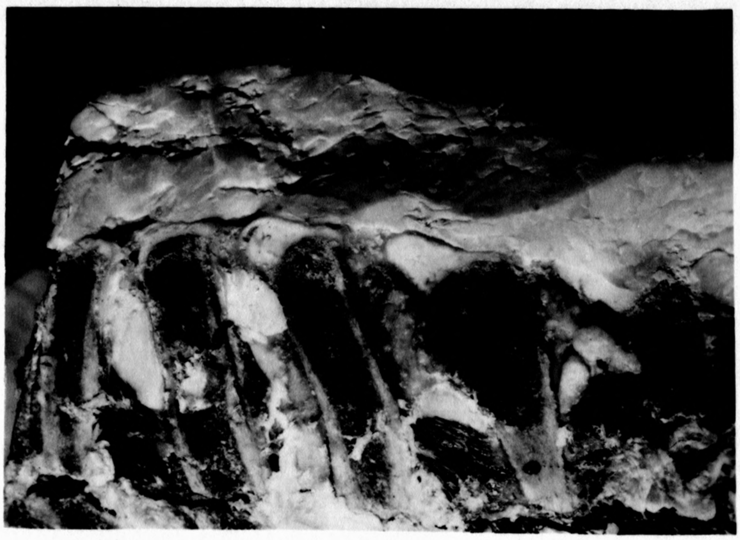

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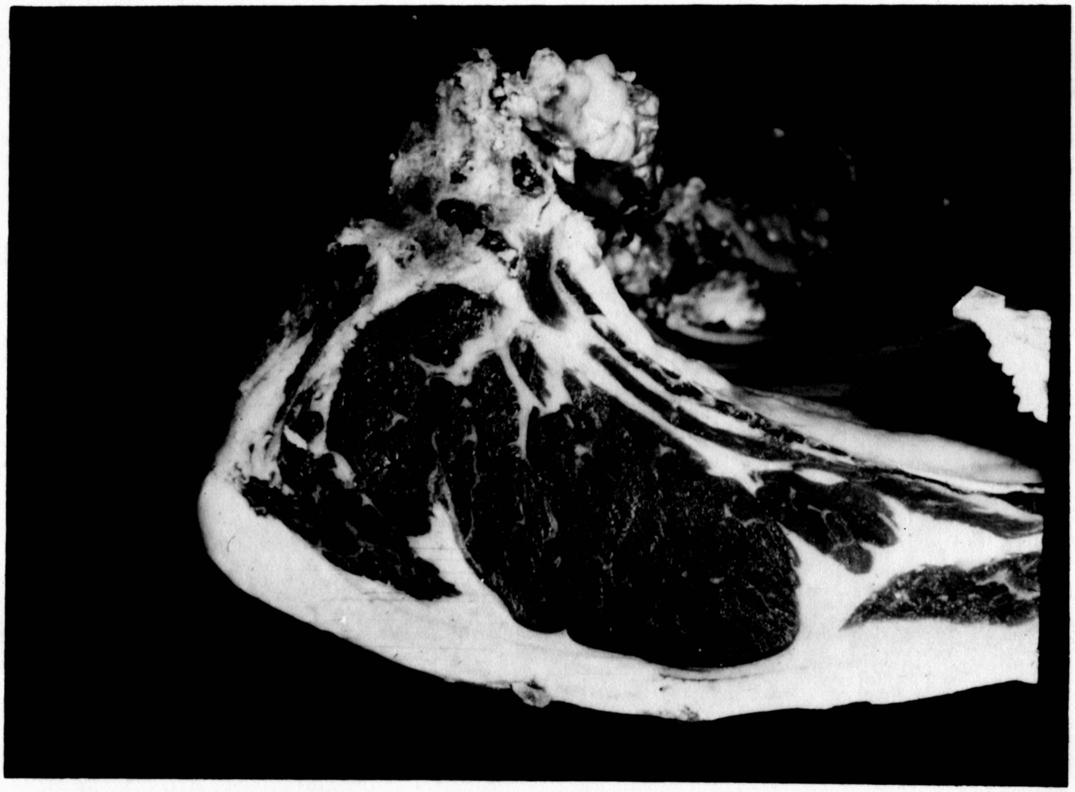
Fig. 3. Marbling levels used as determined by intramuscular fat content.

1. Slight marbling

2. Moderate marbling



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Husbandry at Kansas State University selected all of the carcasses from two packing houses. The rib sections of each carcass were brought to the meat processing laboratory at Kansas State University and sampled. The steaks were cut from the ribs, wrapped in laminated freezer paper, frozen at -20°F and held at -20°F for approximately three to five months. They were thawed at room temperature (about 78°F) for approximately four hours, then put into the refrigerator at 40°F for 20 hours, and were cooked at 400°F by a modified broiling method (Hay et al., 1952) to an end point temperature of 70°C. The design for cooking consisted of 30 periods with four steaks, randomized by pairs (left and right), cooked at each period (Table 1).

Organoleptic and Shear Values

Samples for evaluation were obtained from the steaks as indicated by Fig. 4. An "experienced" panel of 10 to 14 members evaluated the palatability of the steaks on a seven point scale using the score sheet and instructions to the judges presented in the Appendix, pp. 48-50. One-half inch cubes were selected at random by the panel.

To obtain Warner-Bratzler shear values three ½-in. cores were cut from each steak on the lateral side (Fig. 4), cutting with the grain of the tissue. Two shears were made on each core giving a total of six shear values per steak.

Table 1. Random distribution[a] among cooking periods of 120 rib steaks from 60 carcasses.

Cooking period	Steak codes	Cooking period	Steak codes	Cooking period	Steak codes
1	YM2L - YM2R YM9L - YM9R	11	IS5L - IS5R YS7L - YS7R	21	YM8L - YM8R IS10L - IS10R
2	MS9L - MS9R IM9L - IM9R	12	MS5L - MS5R YS3L - YS3R	22	IS9L - IS9R YM7L - YM7R
3	MS2L - MS2R YM1L - YM1R	13	IS2L - IS2R YS2L - YS2R	23	MM1L - MM1R MS4L - MS4R
4	YS8L - YS8R MS6L - MS6R	14	YM4L - YM4R IM10L - IM10R	24	MM7L - MM7R IM6L - IM6R
5	MS8L - MS8R YM5L - YM5R	15	IM3L - IM3R IM5L - IM5R	25	IM7L - IM7R MS3L - MS3R
6	MM2L - MM2R IM2L - IM2R	16	YS4L - YS4R MM3L - MM3R	26	MM8L - MM8R MM5L - MM5R
7	IM8L - IM8R MM6L - MM6R	17	YS10L - YS10R YS1L - YS1R	27	YM6L - YM6R IM4L - IM4R
8	MM10L - MM10R IS7L - IS7R	18	YS6L - YS6R YM10L - YM10R	28	MS7L - MS7R IM1L - IM1R
9	IS1L - IS1R IS4L - IS4R	19	YS5L - YS5R IS8L - IS8R	29	YS9L - YS9R MM9L - MM9R
10	IS6L - IS6R MM4L - MM4R	20	YM3L - YM3R IS3L - IS3R	30	MS10L - MS10R MS1L - MS1R

[a]Randomized by pairs (one pair = one steak from the left and one from the right side of the carcass)

Level of Maturity	Level of Marbling	
		Left (L)
Youthful (Y)	Small (S)	Right (R)
Intermediate (I)	Moderate (M)	1-10, Steak numbers at each level of maturity and marbling
Mature (M)		

Fig. 4. Plan for sampling the LD muscle.

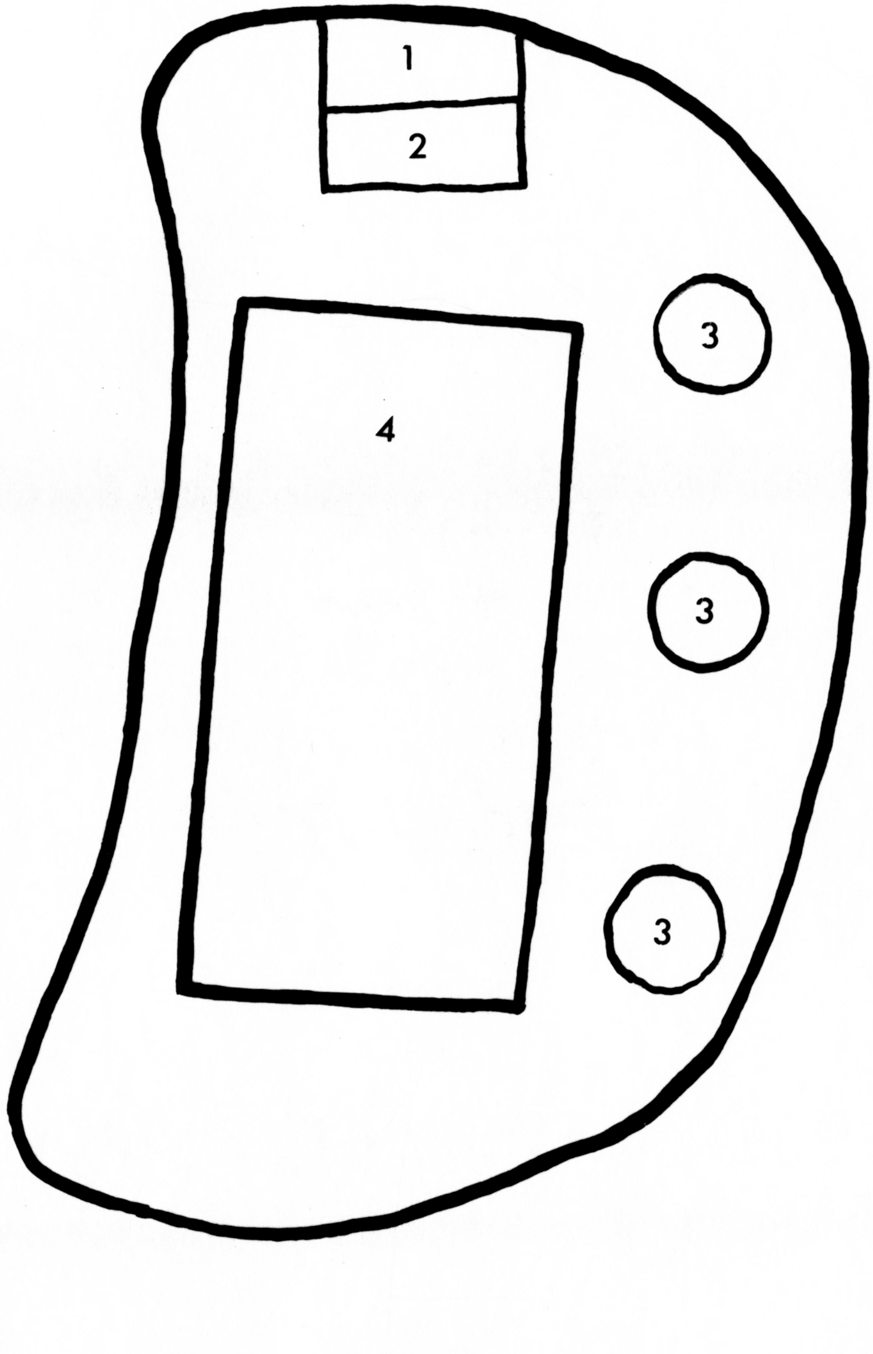
Histological samples, approximately 2 x 1.5 x 0.5 in.

1. Raw muscle

2. Cooked muscle

3. Warner-Bratzler shear cores

4. Organoleptic samples (½-in. cubes)


1
2
3
4
3
3

Histological Estimates

Histological samples from raw and cooked muscle were wrapped in plastic bags (Fig. 5), frozen (-20^{o}F) immediately and held in storage at -20^{o}F. Sections were prepared for study within approximately 8 to 12 weeks after freezing. The order of preparing the sections for histological study was the same as that followed for cooking the steaks (Table 1) until five specimens from each variable (maturity and marbling level) were prepared for study. A specimen of muscle was cut from each sample (about 1$\frac{1}{2}$ x 1 x $\frac{1}{2}$ cm) and sectioned on a CTD International Harris Cryostat microtome to a thickness of 8 u. Five sections from each raw and cooked specimen were mounted on microscopic slides containing a thin layer of albumin fixative and stained with Harris Hematoxylin and Sudan IV as described by Ely (1965).

Three persons evaluated each section using the score sheet and instructions in the Appendix, pp. 51-53. An occular Micrometer in the eyepiece of a Bausch and Lomb Dynazoom Microscope was used to obtain the measurement for fiber width with a magnification of 430x as explained in the Appendix, p. 54. A magnification of 100x was used for observations of the quantity and distribution of fat, because this allowed a larger field of view of the section at one time than would be possible with greater magnification. The slide was moved back and forth until the entire section was viewed before judgements for quantity and distribution of fat were given and recorded on the score sheet. One person also evaluated the sections for quantity and distribution

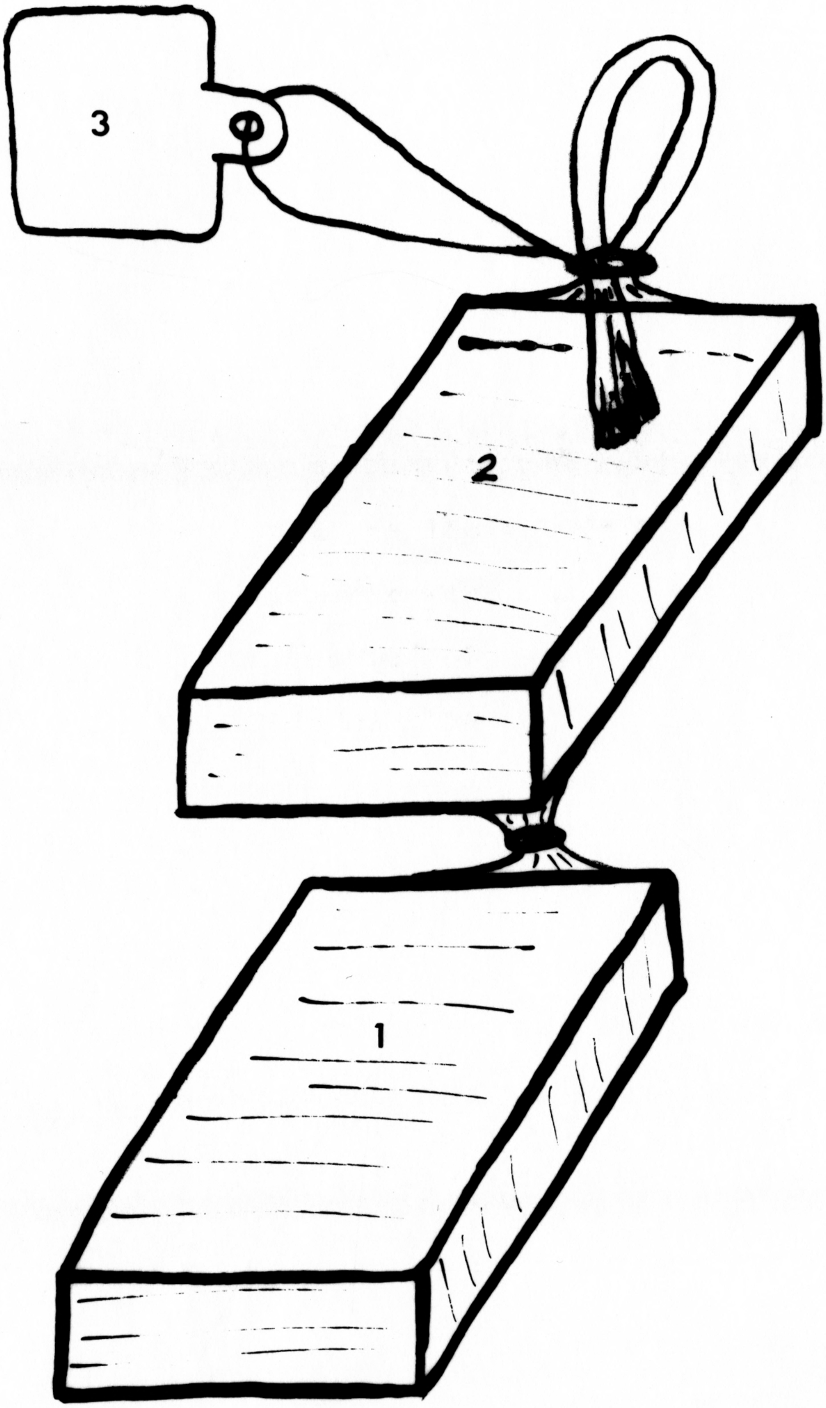
Fig. 5. Preparation of histological samples for frozen storage.

Histological samples

1. Raw muscle

2. Cooked muscle

3. Code label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2
1

of fat using a Bausch and Lomb Microprojector. Each slide was projected onto graph paper with 20 x 20 squares to the inch (Fig. 6). Each of those squares represented 0.1 mm on the slide as measured by focusing a Lovins Micro-Slide Field Finder onto the graph paper. The distance between the slide and graph paper was 23 3/8 in. The area of fat projected in 3,000 squares on the graph paper was colored on the paper. The number of squares colored were counted to obtain the area of fat per 300 sq mm on the slide.

Statistical Analysis

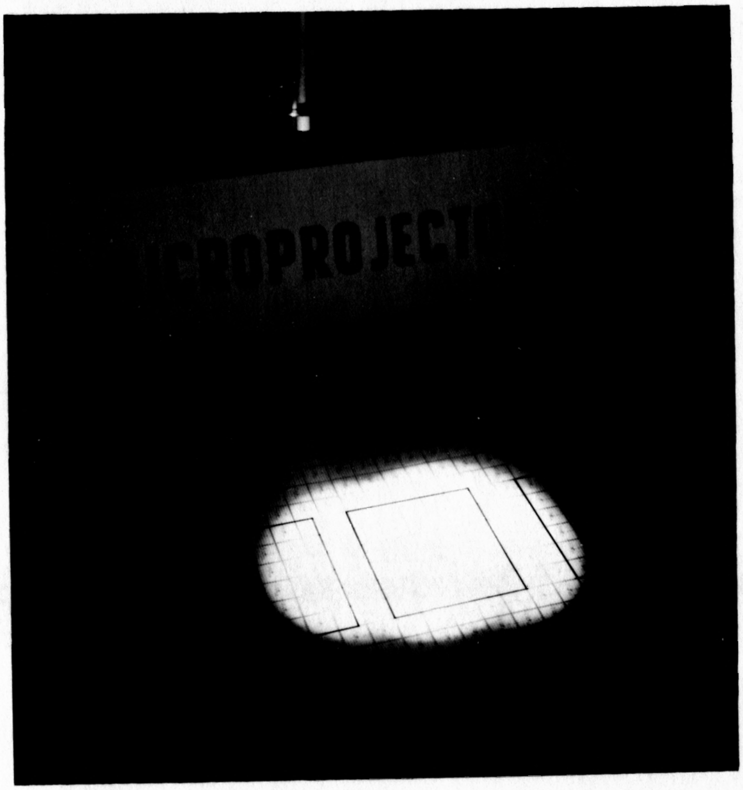
Data were analyzed by analysis of variance as for a completely randomized design to study differences attributable to maturity and marbling levels and differences between the left and right sides of the carcass. Orthogonal comparisons and least significant differences at the 5% level were used to determine differences between specific levels of maturity. Also, correlation coefficients were calculated to study relationships between over-all acceptability and the other organoleptic factors, and between selected organoleptic factors and histological characteristics of the LD muscle.

The analysis to study differences attributable to maturity and marbling (data for left and right sides of the carcass pooled) was:

Fig. 6. Method of section evaluation using the microprojector.

1. Measurement of squares with field finder

2. Measurement of fat area per 3,000 squares on graph paper



1

2

Source of Variation	D/F
Treatments	5
Error	114
Total	119

The analysis to study differences between the left and right sides of the carcass and for analysis of histological data was:

Source of Variation	D/F
Treatments	5
Error	54
Total	59

RESULTS AND DISCUSSION

In the experimental design steaks were randomized by pairs among 30 cooking periods with one steak from the left and one from the right side of the carcass composing a pair. There were few significant differences attributable to side of the carcass or to cooking period. Thus, data for left and right sides of the carcass were pooled and analyzed as for a completely randomized design.

Effect of Maturity and Marbling on Warner-Bratzler Shear and Organoleptic Values

Panel scores for tenderness, juiciness, flavor, and over-all acceptability and Warner-Bratzler shear values were not affected by level of maturity or marbling (Table 2). Several workers

Table 2. Means and standard deviations[a], F-values, and LSD attributable to maturity and marbling.

Factor	Youthful Small	Youthful Moderate	Intermediate Small	Intermediate Moderate	Approaching maturity Small	Approaching maturity Moderate	F-value	LSD[b]
Tenderness								
Score[c]	5.4 (0.9)	5.9 (0.4)	5.8 (0.4)	5.6 (0.4)	5.7 (0.3)	5.8 (0.5)	1.12 ns	
Shear value, lb/½-in. core	5.6 (1.6)	5.2 (0.8)	5.7 (1.0)	5.3 (0.9)	5.3 (0.9)	5.5 (1.0)	0.57 ns	
Juiciness score[c]	6.0 (0.3)	5.9 (0.4)	6.0 (0.5)	5.6 (1.4)	5.8 (0.4)	5.9 (0.6)	0.96 ns	
Flavor score[c]	5.8 (0.3)	5.8 (0.3)	5.8 (0.3)	5.5 (1.3)	5.6 (0.3)	5.8 (0.4)	1.19 ns	
Over-all acceptability score[c]	5.6 (0.6)	5.7 (0.3)	5.8 (0.4)	5.4 (1.3)	5.6 (0.3)	5.8 (0.5)	0.78 ns	
Fat quantity, 1-7								
Raw	3.1 (0.7)	4.3 (0.7)	3.2 (0.5)	3.9 (0.8)	3.7 (0.8)	3.9 (0.7)	3.67 **	0.65
Cooked	4.8 (1.1)	4.8 (1.2)	4.5 (1.1)	4.8 (0.8)	4.7 (1.1)	5.2 (0.6)	0.53 ns	
Ether extract[d]	16.5 (2.8)	22.2 (4.2)	17.5 (1.7)	21.7 (3.3)	17.3 (2.7)	24.2 (4.8)	17.34 ***	2.16
Fat distribution, 1-7								
Raw	4.8 (0.8)	5.5 (0.7)	5.1 (0.8)	5.6 (0.6)	5.2 (0.9)	5.5 (0.6)	1.36 ns	
Cooked	4.6 (0.9)	4.9 (1.0)	4.6 (0.9)	4.6 (0.6)	4.9 (1.1)	4.8 (1.0)	0.21 ns	
Microprojector fat value[e]								
Raw	5.1 (4.1)	7.3 (3.8)	3.6 (1.9)	12.5 (16.5)	7.0 (4.4)	8.3 (4.9)	1.61 ns	
Cooked	7.3 (5.4)	12.3 (12.5)	6.5 (3.5)	10.0 (5.9)	14.7 (14.4)	12.3 (5.6)	1.30 ns	
Fiber width, u								
Raw	38.4 (6.1)	39.9 (3.5)	43.2 (3.3)	39.2 (5.1)	38.9 (4.4)	41.8 (3.4)	1.83 ns	
Cooked	35.5 (6.3)	38.8 (3.9)	36.9 (1.7)	38.6 (2.5)	38.1 (5.2)	38.1 (3.5)	0.71 ns	

[a]Values in parenthesis are standard deviations.

[b]LSD = least significant difference at 5% level.

[c]Range, 7 (very tender, juicy, desirable flavor and over-all acceptability to 1 (extremely tough, dry, undesirable flavor or acceptability).

[d]Percentage lipid, moisture free basis. Data furnished by the courtesy of Dr. H. J. Tuma, Department of Animal Husbandry.

[e]Fat area per 300 sq mm in each section at 16.1 magnification.

ns, not significant.

**, significant at the 1% level.

***, significant at the 0.1% level.

reported similar results.

Tenderness. Field et al. (1966) reported that when marbling was held constant, maturity determined by chronological age had no significant effect on shear values or tenderness scores. Other workers indicated a low and nonsignificant relationship between tenderness and marbling score (Romans et al., 1965; Walter et al., 1965; and Wellington and Stouffer, 1959).

Juiciness. Several workers agreed that juiciness was not affected by maturity level (Goll et al., 1965; Henrickson and Moore, 1965; Lowe and Kastelic, 1961; Ritchey and Hostetler, 1964; Romans et al., 1965; and Tuma et al., 1963), while Goll et al. (1965) found that juiciness was not affected by marbling level. In a review of the relationship of marbling to palatability, Blumer (1963) reported that juiciness was approximately 16% attributable to fat content.

Flavor. Tuma et al. (1963) reported that animal age only slightly influenced flavor scores, and Romans et al. (1965) found that although significant differences did not occur, the flavor of younger animals was preferred to that of older animals. They also reported that flavor was not affected by marbling.

Over-all acceptability. Ho and Ritchey (1967) found that age had little total effect on the eating quality of beef, whereas it appeared to Goll et al. (1965) that wide extremes in carcass maturity influenced eating quality of beef a great deal more than wide extremes in marbling. Ritchey and Hostetler (1964) reported that for animals ranging from 32 to 62 weeks of age only isolated data pointed to any influence of age on acceptability. A lack of significant organoleptic differences, except for juiciness, among marbling levels suggested to Romans et al. (1965) that the effect of marbling on palatability may be overemphasized. In consumer testing of beef from animals of different age Dunsing (1959) found eating preferences consistently in favor of steaks from younger animals, especially for the sirloin cut. On the other hand, visual preferences of panel members differed by wholesale cut. Steaks from older animals were preferred for the short loin and steaks from younger animals for the sirloin. About half of the panel members indicated a different preference for visual and eating qualities of the paired steaks presented. The results suggested that panel members differed in the relative importance they attached to specific factors in terms of providing eating satisfaction.

Similar to analysis of variance, orthogonal comparisons of palatability scores and Warner-Bratzler shear values showed no significant effect of maturity and marbling. However, orthogonal comparisons of flavor scores indicated a significant ($P < 0.05$) interaction between maturity and marbling and the interaction was nearly significant for panel scores for tenderness and over-all acceptability.

On the basis of panel scores for all palatability factors and Warner-Bratzler shear values, Bartlett's test of homogeneity of variance indicated a high degree of variation among the steaks. Chi square values ranged from 63.9 to 93.6 for the palatability factors and the chi square for the Warner-Bratzler shear values was 11.21. A value of 11.07 at five degrees of freedom is required for a significant ($P < 0.05$) variation. The high degree of variation among the steaks for palatability factors may be attributable to variation in palatability scores assigned to the steaks by individual panel members and/or to variation among the steaks themselves. The heterogeneity of panel scores may explain, in part, the nonsignificant differences in palatability of steaks from the three maturity and two marbling levels.

Effect of Maturity and Marbling on Histological Values and Ether Extract

Fat quantity (cooked sections), fat distribution (raw and cooked sections), microprojector fat values (raw and cooked sections), and fiber width (raw and cooked sections) were not affected by maturity and marbling levels (Table 2). Fat quantity (raw sections) and ether extract values were affected significantly ($P < 0.05$) both by maturity and marbling levels.

Fat quantity. Both methods of evaluating the quantity of fat in raw tissue (histological estimates and ether extract values) were affected significantly, ($P < 0.01$) and ($P < 0.001$), respectively, by maturity and marbling levels (Table 2). Orthogonal comparisons and least significant differences (LSD) of means indicated that these differences could be attributed to the two marbling levels studied, with the moderate level containing slightly more fat. Orthogonal comparisons for histological estimates attributed some of the difference to an interaction between maturity (differences between youthful and approaching maturity) and marbling, although most of the differences were attributed to marbling. Differences between mean values were more pronounced for ether extract values than for microscopic estimates of quantity of fat. Ether extract values were much more heterogeneous. The microscopic estimates for quantity of fat (cooked sections) were not affected by maturity or marbling level. McBee and Wiles (1967) found that ether extract values showed a higher percentage of lipid in B than in A maturity levels, but in most cases differences were small. Several workers reported high and significant correlation between ether extract (MFB) and marbling scores (Kropf and Graf, 1959; McBee and Wiles, 1967; Moody, 1967; Romans et al., 1965; Walter et al., 1965; and Wellington and Stouffer, 1959). Moody (1967) reported that histologically estimated fat increased with marbling level.

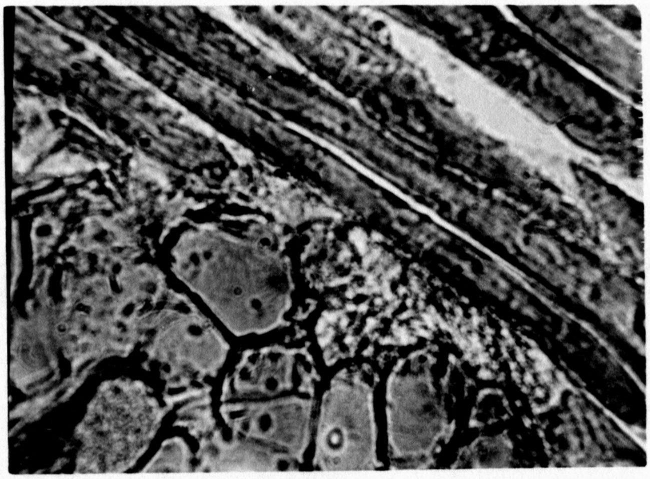
Fat distribution. F-values indicated that histological estimates of fat distribution were not affected significantly by maturity and marbling levels (Table 2). However, orthogonal comparisons revealed that fat distribution scores for raw tissue were affected significantly by marbling level with the moderate marbling level containing larger fat droplets. Figure 7 illustrates the difference in size of fat droplets observed in sections of tissue from the two marbling levels.

Microprojector fat value. Microprojector fat values were used as a combination score for fat quantity and fat distribution since it measured the amount of fat per 300 sq mm on a section.

Fig. 7. Effect of marbling level on fat distribution.

1. Intermediate maturity, moderate marbling. Note large area of fat at lower left hand part of the photomicrograph.

2. Intermediate maturity, small marbling. Areas of fat are smaller than in the photomicrograph representing moderate marbling.



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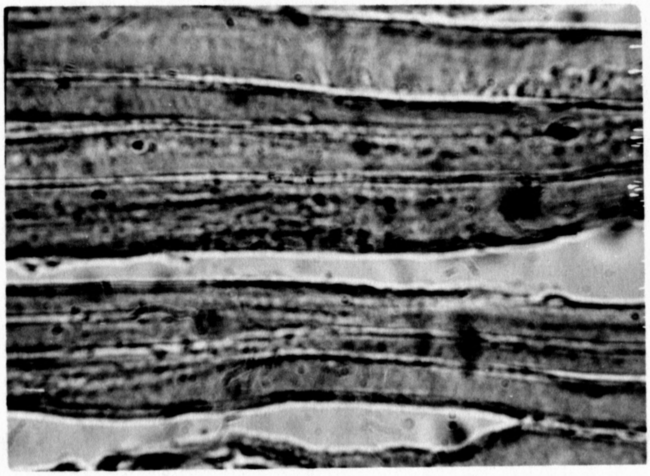

2

This value was not significantly affected by maturity or marbling level. Values for raw sections however, showed a significant ($P < 0.05$) effect of marbling when orthogonal comparisons were studied, with the moderate marbling levels containing more fat.

Differences between right and left sides were significant ($P < 0.05$) for the raw tissue microprojector fat values. This was unexplained since no other measurement showed significant differences between the two sides of the carcass. Orthogonal comparisons indicated an interaction between marbling level and youthful and approaching maturity levels. All combinations of maturity and marbling were significantly different from the intermediate maturity moderate marbling group when data for right and left sides of the carcasses were separated. A high standard deviation for the intermediate-moderate level may partially explain this difference.

Fiber width. Although analysis of variance of data for sections from raw tissue indicated that fiber width was not affected by marbling and maturity level, orthogonal comparisons indicated that small and moderate levels of marbling exhibited different trends. With a small degree of marbling, the intermediate maturity level had wider fibers than young or approaching maturity; whereas at the moderate marbling level, the intermediate maturity level exhibited narrower fibers than either the youthful or approaching maturity levels. Cooked fiber width was not significantly affected by maturity or marbling levels. Romans et al. (1965) found no significant differences in fiber width between A and B maturity level steaks.

Cross-striated fibers. The occurrence of cross-striations on the muscle fibers was noted by the microscopic viewers. In all sections studied, the majority of the fibers had prominant cross-striations, and a few fibers had no cross-striations. There was a tendency for fibers in tissue with moderate marbling to have more prominant cross-striations than fibers in tissue with a small amount of marbling. There were some differences among maturity levels (Table 3).

Table 3. Occurrence of cross-striated fibers.

Treatment	Cross-striation visibility		
	Prominant	Visible	Not visible
Youthful maturity			
Small marbling	162	123	15
Moderate marbling	190	108	2
Intermediate maturity			
Small marbling	142	129	29
Moderate marbling	180	108	12
Approaching maturity			
Small marbling	161	129	10
Moderate marbling	169	121	10

Correlation Coefficients for Selected Variates on the Basis of Maturity and Marbling Levels

Correlation coefficients were computed to study relationships between selected measurements of the characteristics of rib steaks. A high correlation coefficient (an r value close to 1.0) indicates a good relationship between the two measurements, i.e.

they measured the same thing.

Correlation coefficients within each of the three maturity levels (youthful, intermediate and approaching maturity) and two marbling levels (small and moderate) for selected variates are reported in Table 4. Correlation coefficients are for eight degrees of freedom, and are significant at the 5% level, if disregarding sign, the value is at least 0.632. A wide range of correlation coefficients was noted for most of the relationships studied within each of the three levels of maturity and two levels of marbling. Some significant relationships were noted.

In general, correlation coefficients indicated a higher relationship between over-all acceptability vs. the palatability factors (flavor, juiciness, and tenderness) and among the measurements used for the evaluation of fat (microscopic fat quantity and distribution, microprojector fat values and ether extract scores) than among other measurements for evaluation. Few significant relationships (r-values) were obtained between the palatability factors and any of the objective measurements. A higher relationship was noted between histological scores from cooked steaks and other measurements than between histological scores from raw steaks and other variates.

SUMMARY

LD steaks from the 11th thoracic region (120, 2 in. thick) representing three maturity levels (youthful, intermediate, and approaching maturity) and two marbling levels (small and moderate)

Table 4. Correlation coefficients for selected variates on the basis of maturity and marbling level.

Paired variates	Maturity and marbling levels					
	Youthful		Intermediate		Approaching maturity	
D/F = 8	Small	Moderate	Small	Moderate	Small	Moderate
Over-all acceptability score vs.						
Flavor score	0.73*	0.05	0.76**	0.51	0.58	0.83**
Juiciness score	0.66*	-0.07	0.41	0.62	0.34	0.80**
Tenderness score	0.97***	0.25	0.54	0.88***	0.62	0.80**
Fiber width, cooked	-0.82**	0.28	-0.10	0.27	-0.20	0.42
Fat quantity, cooked	-0.20	0.00	0.53	0.35	0.12	0.67*
Fat distribution, cooked	0.36	-0.43	0.82**	-0.24	0.54	-0.67*
Microprojector fat value, cooked	-0.03	0.37	0.60	0.10	0.02	-0.08
Warner-Bratzler shear value vs.						
Tenderness score	-0.65*	0.18	0.17	-0.41	-0.04	-0.77**
Fiber width, cooked	0.65*	0.78**	-0.14	-0.23	-0.58	-0.14
Fat quantity, cooked	0.20	0.32	-0.22	-0.60	0.00	-0.47
Fat distribution, cooked	0.03	-0.04	-0.02	-0.20	-0.02	0.13
Microprojector fat value, cooked	0.05	0.49	-0.39	-0.47	-0.23	0.13
Fiber width, raw	-0.11	0.41	-0.06	0.24	-0.43	0.28

Table 4. (continued)

Paired variates	Maturity and marbling levels					
	Youthful		Intermediate		Approaching maturity	
D/F = 8	Small	Moderate	Small	Moderate	Small	Moderate
Tenderness score vs.						
Fiber width, cooked	-0.73*	-0.01	-0.25	0.19	0.00	0.31
Fat quantity, cooked	-0.07	0.39	0.48	0.48	-0.05	0.66*
Fat distribution, cooked	0.40	0.44	0.60	-0.07	-0.18	-0.04
Microprojector fat value, cooked	0.08	0.48	0.48	0.27	-0.04	0.07
Fiber width, raw	-0.16	0.44	0.27	-0.48	-0.05	-0.27
Fat quantity, raw	0.56	-0.15	-0.21	0.57	-0.07	0.08
Fat distribution, raw	0.52	-0.31	-0.03	0.52	0.06	0.11
Microprojector fat value, raw	0.40	-0.44	-0.31	-0.31	0.04	-0.30
Juiciness score vs.						
Fat quantity, cooked	0.00	0.23	-0.09	0.02	0.21	0.63
Fat distribution, cooked	-0.01	0.56	0.34	-0.70*	0.60	0.10
Microprojector fat value, cooked	-0.23	-0.01	-0.15	-0.38	0.01	0.14
Fat quantity, cooked vs.						
Fat distribution, cooked	0.48	0.86**	0.37	0.64*	0.75*	0.18
Microprojector fat value, cooked	0.76*	0.77**	0.61	0.83**	0.70*	0.25

Table 4. (concluded)

Paired variates	Maturity and marbling levels					
	Youthful		Intermediate		Approaching maturity	
D/F = 8	Small	Moderate	Small	Moderate	Small	Moderate
Ether extract vs.						
Fat quantity, cooked	0.84**	0.81**	0.19	0.28	0.28	0.69*
Fat distribution, cooked	0.39	0.86**	-0.19	-0.18	0.16	0.24
Microprojector fat value, cooked	0.70*	0.50	-0.28	-0.01	0.37	0.34
Fat quantity, raw	0.02	-0.74*	-0.05	0.01	0.62	0.59
Fat distribution, raw	-0.23	-0.57	-0.03	-0.05	0.42	0.45
Microprojector fat value, raw	0.10	-0.80**	-0.14	-0.24	0.49	0.28
Juiciness score	0.30	0.56	0.51	0.52	-0.13	0.63*
Raw vs. Cooked						
Fiber width	0.48	0.46	0.16	0.15	0.48	-0.37
Fat quantity, 1-7	0.12	-0.65	0.10	0.33	0.31	0.55
Fat distribution, 1-7	0.46	-0.58	-0.21	-0.15	0.31	-0.11
Microprojector fat value	0.42	-0.45	0.19	-0.41	-0.42	-0.02

*, = P = 0.05
**, = P = 0.01
***, = P = 0.001

Levels of significance:

df	0.05	0.01	0.001
8	0.632	0.765	0.872

were used to investigate the effect of maturity and marbling on selected characteristics of beef.

Warner-Bratzler shear values and panel scores for tenderness, juiciness, flavor, and over-all acceptability were not affected by level of maturity and marbling. Likewise histological estimates for fat quantity (cooked sections), fat distribution (raw and cooked sections), microprojector fat values (raw and cooked sections) and fiber width (raw and cooked sections) were not affected significantly by maturity and marbling level. Fat quantity determined histologically (raw sections) and ether extract values (MFB) were affected significantly, ($P < 0.01$) and ($P < 0.001$) respectively, by maturity and marbling levels. Analysis of data indicated that the difference could be attributed primarily to differences between the two marbling levels studied.

Few significant relationships (r-values) were obtained between the palatability factors and any of the objective measurements. However, relationships among the measurements used for the evaluation of fat and between over-all acceptability vs. the palatability factors were higher.

On the basis of this study it was concluded that the levels of marbling and maturity represented had little effect on the palatability of the steaks even though the fat content (raw histological fat quantity and ether extract scores) was higher at the higher level of marbling.

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APPENDIX

SCORE CARD FOR BEEF RIB STEAKS

Judge ____________________ Code ____________________________ Date ________________________

Sample No.	Desirability of Flavor	Juiciness	Tenderness: No. chews	Tenderness: Score	Over-all acceptability	Comments
1						
2						
3						
4						

Descriptive terms for scoring:

<u>Desirability of Flavor</u>

7. Extremely desirable
6. Desirable
5. Moderately desirable
4. Acceptable
3. Slightly undesirable
2. Undesirable
1. Extremely undesirable

<u>Juiciness</u>

7. Extremely juicy
6. Juicy
5. Moderately juicy
4. Acceptable
3. Slightly dry
2. Dry
1. Extremely dry

<u>Tenderness</u>

7. Extremely tender
6. Tender
5. Moderately tender
4. Acceptable
3. Slightly tough
2. Tough
1. Extremely tough

<u>Over-all acceptability</u>

7. Extremely desirable
6. Desirable
5. Moderately desirable
4. Acceptable
3. Slightly undesirable
2. Undesirable
1. Extremely undesirable

INSTRUCTIONS TO JUDGES FOR SENSORY EVALUATION OF RIB STEAKS

Scoring for tenderness

You may use one cube of meat to score tenderness and another cube to score flavor and juiciness. Count the number of times you chew the $\frac{1}{2}$-in. cube of meat before swallowing. Chew until the cube of meat is completely masticated, then swallow. Record the number of chews required to masticate the cube. Record a score from 7 to 1 that describes your impression of the tenderness of the cube. See the score card for descriptive terms for specific scores within the range of 7 to 1.

Use the number of chews to help you standardize your tenderness scores from day to day. Set up for yourself a range of number of chews for each score from 7 to 1. For example, if you chew from 15 to 25 times, you might record a score of 7; if you chew 25 to 35 times, a score of 6; 35 to 45, a score of 5; continuing to reduce the score by a given number of increased chews. Each judge sets his own range of chews for a given score.

Scoring for flavor and juiciness

Record a score for flavor and another for juiciness within a range of 7 to 1 that describes your impression of the sample. See the score card for descriptive terms for specific scores within the range of 7 to 1.

After you are accustomed to scoring, you may be able to score flavor and juiciness on the same cube of meat that you use to score tenderness. If you do this, record the score describing your impression of flavor and juiciness at the beginning of the chewing process.

Over-all acceptability

Record a score that describes your impression of the general desirability of the sample. This is not a total score, i.e., it is not a score obtained by adding the scores for the other factors listed on the score card. The score for over-all acceptability is within the range of 7 to 1, the same as for each of the other factors listed on the score card.

Comments

Comments about a sample and/or explaining your reason for giving a particular score are helpful.

Take your time to score each sample. Water is provided for rinsing your mouth between each sample. If you use two cubes of meat, it is not necessary to swallow the cube used to score flavor and juiciness.

SCORE CARD FOR HISTOLOGICAL EVALUATION OF LD MUSCLE FROM BEEF RIB STEAKS

Code no. ______________ Name ______________

Factor	Section number					Total	Av.
	1	2	3	4	5		
Muscle fibers							
Fiber width, mm. (430x) A.							
B.							
C.							
Cross-striations check observation							
Prominant							
Visible							
Not visible							
Fat							
Relative quantity[a]							
Fat distribution[b]							

<u>Quantity</u>[a]

7 - Large
5 - Medium
3 - Small
1 - None

<u>Distribution</u>[b]

7 - Large droplets
5 - Medium droplets
3 - Small droplets
1 - Cloudy aggregate of fat

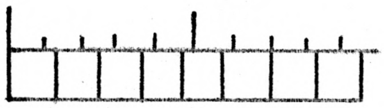
A, B, and C refer to three measurements made on each section by each evaluator.

MICROSCOPIC MEASUREMENT OF FIBER WIDTH

The virtual image of a tiny scale is engraved on a clear glass disc, the ocular micrometer. Insert this disc into the eyepiece by unscrewing the top lens and inserting the disc onto the shelf within the eyepiece. This disc is marked off in equal units with the center further divided into smaller units.

In order to measure the magnified image, the units on the ocular disc are compared to a stage micrometer. This is a slide with a measurement line divided into 0.01 mm units. To do this, insert the slide on the stage of the microscope under high power (43X objective and 10X eyepiece). Set the Dynazoom knob on the microscope at position 1 to give a magnification of 430X. Match a line of the scale on the stage micrometer with a line on the squared scale of the ocular (eyepiece) micrometer. Count the number of ocular and stage units until another line on the ocular matches another line on the stage micrometer.

Example:



7 stage units
6 ocular units

Determine the distance covered by the ocular units. Each unit on the stage micrometer equals 0.01 mm, see slide. There were 7 stage units counted so 0.07 mm is the same measurement as 6 magnified ocular units. Divide the distance in the stage micrometer by the corresponding number of units in the ocular micrometer to determine the actual size of each ocular unit.

Example: 7 stage units = 7 X 0.01 or 0.07 mm.

$$\frac{0.07}{6} = 0.012 \text{ mm/ocular unit or}$$

1 ocular unit = 0.012 mm.

Replace the stage micrometer with the slide to be studied. The width of the muscle fibers can be obtained by counting the number of units which correspond to the width of a fiber and multiplying that by the size of the unit of measure.

Example: muscle fiber width = 3 ocular units

3 X 0.012 mm = 0.036 mm for that fiber's width

Convert the mm value to μ by multiplying by 1000.

0.036 mm X 1000 = 36 μ

Notes. Through the center of the eyepiece, the ocular units are further divided into 5 parts. These may be used in measurements for greater accuracy.

The eyepiece can be turned in the tube, thus turning the ocular scale. In this way, fibers can be measured even though they do not lie in a perfectly vertical or horizontal direction.

For each section select at random 3 fibers, measure, calculate width in μ, and enter on score sheet.

Once the ocular micrometer has been set up, it should not be removed. If the disc is removed from eyepiece, the calibrations for unit determinations need to be repeated for each magnification used as turning disc over changes the calibration readings.

OCULAR MICROMETER DETERMINATIONS

In deciding which magnification to use in fiber diameter determinations two criteria were considered. First, the ease of locating the fibers and reading the scale were considered; and second, the accuracy of the measurement. At lower magnifications, the fibers were easier to locate. At higher magnifications, there was more accuracy as each unit on the ocular micrometer represented fewer microns. By using four magnifications for reading, it was concluded that 430X was the lowest magnification that could be used with reasonable accuracy. The results of 10 fiber widths at four magnifications (100x, 200x, 430x, and 860x) can be noted on the chart below.

	Magnification							
	x100		x200		x430		x860	
1 ocular unit =	104 µ		53 µ		24 µ		12 µ	
	Units	µ	Units	µ	Units	µ	Units	µ
Fiber 1	0.1	10.4	0.3	15.9	1.2	28.8	2.4	28.8
2	0.4	41.6	0.8	42.4	1.9	45.6	3.8	45.6
3	0.4	41.6	0.9	47.7	2.0	48.0	4.0	48.0
4	0.1	10.4	0.5	26.5	1.3	31.2	2.6	31.2
5	0.3	31.2	0.6	31.8	1.2	28.8	2.5	30.0
6	0.2	20.8	0.5	26.5	1.3	31.2	2.7	32.4
7	0.3	31.2	0.6	31.8	1.2	28.8	2.4	28.8
8	0.2	20.8	0.6	31.8	1.2	28.8	2.5	30.0
9	0.2	20.8	0.6	31.8	2.4	57.6	4.8	57.6
10	0.4	41.6	0.8	42.4	1.8	43.2	3.6	43.2
Average		27.04		32.86		37.2		35.16

PHOTOMICROGRAPHY

Photomicrographs were taken with a Polaroid Land Camera (model 80B, attachable to the Bausch and Lomb Dynazoom Microscope). Pola Pan 400 Polaroid Film, Type 32, was loaded into the camera as directed by "How to make good pictures with your Polaroid Highland Land Camera." In order to attach the camera to the microscope, the large screw was removed from the top of the microscope and a camera adapter sleeve was screwed in. The camera was fit into the sleeve and locked in place with the lock screw in the side of the sleeve. After the area to be photographed was located on each slide and focusing was completed, the prism control knob was turned to the "out" position for taking the photograph. The Base Illuminator dial was set at four, and the exposure time in the camera at 1/10 of a second. The zoom knob on the microscope was set at 1.5X and the 10X objective was used to give a magnification of 150. The picture was taken and developed as directed in the Polaroid instructions. The developing time was 10 seconds.

EFFECT OF MATURITY AND MARBLING LEVEL OF THE BEEF CARCASS ON HISTOLOGICAL CHARACTERISTICS, TENDERNESS AND JUICINESS OF LONGISSIMUS DORSI

by

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LD steaks from the 11th thoracic region (120, 2-in. thick) representing three maturity levels (youthful, intermediate and approaching maturity) and two marbling levels (small and moderate) were used to investigate the effect of maturity and marbling on selected characteristics of beef.

Warner-Bratzler shear values and panel scores for tenderness, juiciness, flavor, and over-all acceptability were not affected by level of maturity and marbling. Likewise histological estimates for fat quantity (cooked sections), fat distribution (raw and cooked sections), microprojector fat values (raw and cooked sections) and fiber width (raw and cooked sections) were not affected significantly by maturity and marbling level. Fat quantity determined histologically (raw sections) and ether extract values (MFB) were affected significantly, ($P < 0.01$) and ($P < 0.001$) respectively, by maturity and marbling levels. Analysis of data indicated that the difference could be attributed primarily to differences between the two marbling levels studied.

Few significant relationships (r-values) were obtained between the palatability factors and any of the objective measurements. However, relationships among the measurements used for the evaluation of fat and between over-all acceptability vs. the palatability factors were higher.

On the basis of this study it was concluded that the levels of marbling and maturity represented had little effect on the palatability of the steaks even though the fat content (raw histological fat quantity scores and ether extract scores) was higher at the higher level of marbling.