Effects of Animal Age On The Palatability of Beef

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Effect Of Animal Age On The Palatability Of Beef

by

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The prime goal of the meat industry is to furnish the consumer a wholesome, nutritive and palatable product. The consumer must be the prime consideration when standards are formulated, making sure that all criteria are evaluated to produce an acceptable meat product.

Research reported herein was conducted to determine the influence of animal age, variation of muscles and fat level within muscles on the tenderness, juiciness and flavor of beef.

Procedures

Forty carcasses were selected for study from a total of 85 Hereford steers and females. All animals were from the Experiment Station herd and had similar genetic and environmental backgrounds. Cattle of four different age groups, 6, 18, 42 and 90 months, were used. The 18, 42 and 90 month-old animals were pastured on native grasses and fed *ad lib.* a supplemental ration of ground ear corn, chopped alfalfa hay, cottonseed hulls, cottonseed meal, bran, whole oats and molasses. The six-month-old animals were creep fed a ration of predominantly ground milo while on cows for the complete term prior to slaughter. Cattle from the three older groups were fed as near alike as possible, although it is recognized that feed requirements are different for cattle which vary this much in age.

Both steers and heifers were used in the 6 and 18 month old groups but only females were used in the 42 and 90 month age groups.

The cattle were selected from the feedlot herd when they were considered to have the desired amount of marbling by visual appraisal of the live animals. The calves were selected at birth on the basis of their conformation. The genetic potential of the animals caused the "poor doers" to be used for the low marbling level while the "early maturing,

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easily fattened" animals were used in the high level group. No attempt was made to assess the influence of these factors on the quality of the carcass or tissues (Henrickson et al. 1963).

Slaughtering was done following standard procedures. The carcasses were placed in a 34-36°F cooler for a two-day chilling period immediately after the animals were slaughtered and dressed. The carcasses were visually appraised and graded by an official USDA meat grader.

Figure 1 shows the experimental design. The *longissimus dorsi* (shortloin) and *semitendinosus* muscles (round) from one side were studied in detail. The left sides were sampled two days post-mortem (chilled 34-36°F). Sampling locations were identical for each carcass. Figures 2 and 3 shows the location on the muscle from which the samples were taken.

Figure 1—Statistical Design for Each Age Group

Treatment				
Age (Months)	6	18	42	90
Level of Fat (Avg.)	High		Low	
Muscle[1]	LD	ST	LD	ST
No. in Group	5	5	5	5
Total Animals (40)				

[1]LD — *Longissimus dorsi*
ST — *Semitendinosus*

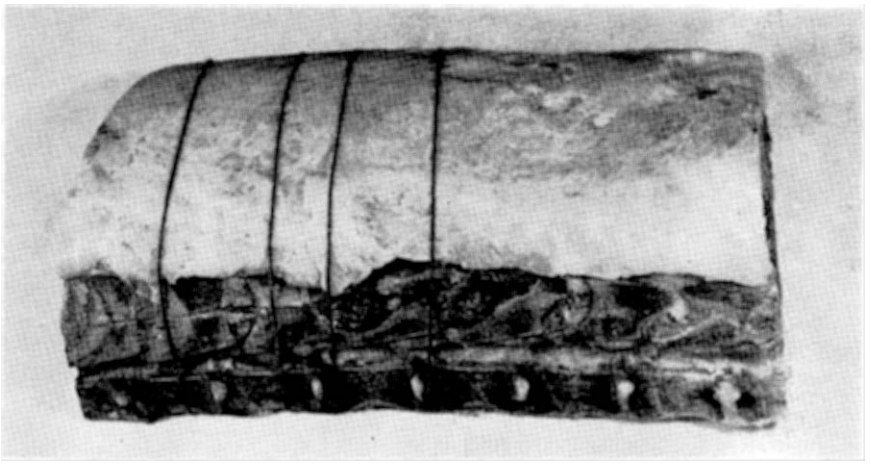

Figure 2. Longissimus dorsi muscle. The samples were taken as shown, anterior to posterior, starting at the first lumbar. The first piece was removed followed by a 2 inch section for shear determination, a 1 inch slice for taste test and a 2 inch section for chemical analysis.

Figure 3. Semitendinosus muscle. The samples were taken origin to insertion. The first 2 inch section was used for shear, followed by a 1 inch slice for taste and a 2 inch section for chemical analysis.

Boned and trimmed steaks from the two muscles were wrapped individually and quick frozen in an air blast freezer at —10°F and then held at —20°F until time of evaluation.

Two-inch steaks were used for shear evaluation and were thawed in a 40°F cooler for 12 hours. They were broiled in an open-faced gas griddle-broiler to an internal temperature of 150°F. After broiling, the temperature of each steak was allowed to equalize before removing cores for shear determination.

Shear values were determined by the Warner-Bratzler device. Three one-inch cores (lateral, medial and dorsal) were removed from the *longissimus dorsi* steaks and three were removed from the *semitendinosus* steaks following a circular pattern. Three shears were made on each core, giving a total of nine values per steak. The average of these nine values was used in the statistical treatment of the data.

Steaks for taste panel use were one-inch thick and broiled in the same manner described earlier. "Bite-size" portions (¾ inch cores) were removed from each steak for the sensory analysis. The sensory panel used throughout this work consisted of meat laboratory personnel. Although the panel was not trained primarily for this study the members were considered competent to evaluate organoleptic properties of the meat. Tenderness, juiciness and flavor were scored on an eight-point hedonic scale (Figure 4), with eight being the highest rating. The senory values used in the statistical data are an average of the panel scores for each of the organoleptic components.

Figure 4—Hedonic Scale for Taste Panel to Score Quality Factors of Individual Steak

	Tenderness		Flavor		Juiciness
8. Extremely Tender	☐	Extremely Desirable	☐	Extremely Juicy	☐
7. Very Tender	☐	Very Desirable	☐	Very Juicy	☐
6. Moderately Tender	☐	Moderately Desirable	☐	Moderately Juicy	☐
5. Slightly Tender	☐	Slightly Desirable	☐	Slightly Juicy	☐
4. Slightly Tough	☐	Slightly Undesirable	☐	Slightly Dry	☐
3. Moderately Tough	☐	Moderately Undesirable	☐	Moderately Dry	☐
2. Very Tough	☐	Very Undesirable	☐	Very Dry	☐
1. Extremely Tough	☐	Extremely Undesirable	☐	Extremely Dry	☐

COMMENTS:

Muscle samples for proximate analysis were trimmed of fat and connective tissue and blended to a paste consistency. Duplicate aliquotes were used for percent moisture and percent ether extract analyses (AOAC, 1945).

Results And Discussion

Even though an effort was made to select calves at birth with superior conformation and encourage them to consume grain from a self-feeder while taking milk from nurse cows, they failed to deposit enough marbling in the *longissimus dorsi* muscle to be scored slightly abundant.

Mechanical Shear

Shear values reported for the 80 individual steaks in this study ranged from 7.2 to 38.7 pounds of force. The general response pattern for Warner-Bratzler shear was practically the same for each age group irregardless of muscle and level of fat (Table 1). The only deviation to this general pattern occurred with the high level *semitendinosus* muscle. The analysis of variance showed that the effect of animal age was highly significant at the one percent level (Table 2). At six months of age the

Table 1—Age × Muscle Means For Shear[1,2]

Age in Months	6	18	42	90	Avg.
Longissimus dorsi	16.8	12.0	19.3	23.1	17.8
Semitendinosus	17.3	15.9	23.3	27.6	21.0

[1]Averaged over both levels of fat.
[2]Expressed in pounds, the greater the number of pounds the less tender the steak.

shear resistance averaged for both muscles was 17 pounds (Table 3). Less pounds of force were needed to shear the steaks from the 18 months old animals than the other three age groups. Meat from this age level was the most tender group studied.

The greatest decrease in tenderness occurred between 18 and 42 months. The *longissimus dorsi* and *semitendinosus* for the four age groups averaged over both levels of fat showed the same trend as the age means (Table 1). The steaks from the 18 month-old cattle were the most tender for both muscles. The *longissimus dorsi* steaks were slightly more tender than the *semitendinosus* steaks but not significantly (Table 2).

When individual muscles in each age group were categorized into low and high fat level according to percentage ether extract, the age × fat level effect was non-significant at the 5 percent level. Table 4 shows the age × fat level means averaged for both muscles. The fat level appears to have the greatest influence on tenderness at the 42 and 90 month ages where a difference of more than five pounds of shear force occurred in favor of the high fat level of each age group.

Table 2—Analysis Of Variance For Shear

Source	df	M.S.	F-test	Sig.[1]
Total	79			
Age	3	248.54	9.23	.01
Fat Level	1	38.78	1.44	NS
Muscle	1	52.49	3.66	NS
Age × Muscle	3	63.72	4.45	.05
Age × Fat Level	3	66.64	2.47	NS
Muscle × Fat Level	1	18.57	1.30	NS
Age × Muscle × Fat Level	3	274.45	19.15	.01
Animal in Age × Fat Level	32	26.94		
Animal × Muscle in Age × Fat	32	14.33		

[1]NS — Not significant at 5 percent level of probability.
.05 — $P < .05$.
.01 — $P < .01$.

Table 3—Age Means For Shear[1]

Age in Months	6	18	42	90
Shear (lb.)	17.0	13.9	21.3	25.4

[1]Combined value for *longissimus dorsi* and *semitendinosus* muscles including both fat levels.

Table 4—Age × Fat Level Means For Shear[1,2]

Age in Months	6	18	42	90	Avg.
Low Fat Level	17.2	13.9	23.9	28.2	20.8
High Fat Level	16.8	14.0	18.7	22.6	18.0

[1]Averaged over both muscles.
[2]Expressed in pounds, the greater the number of pounds the less under the steak.

The three-way interaction of age × muscle × fat level is highly significant at the one percent level. Figure 5 shows that the high fat level *longissimus dorsi* was the the most tender followed by the high fat level *semitendinosus,* the low fat level *longissimus dorsi* and the low fat level *semitendinosus.* A deviation occurs to this pattern between 18 and 42 months of age. The *semitendinosus* muscle with the high fat level became more tender than the low fat level *longissimus dorsi* muscle before the age of 42 months and continued to be more tender through the 90 month age. In the age span of 6 to 18 months an interaction occurred between fat levels of both the *longissimus dorsi* and *semitendinosus* muscles.

This study did not attempt to find the reason for the differences occurring between age groups. It did however, show that variations in tenderness do exist and indicated the trend of this variation as the animal matures.

The steaks reached their maximum tenderness between 6 and 42 months. It is conceivable that at the age where maximum tenderness occurred, the micro-components of fat, muscle fibers and connective tissue fibers may have been at their most favorable relationship with one another for influencing tenderness.

Taste Panel

Taste panel scores for tenderness were different than the Warner-Bratzler shear values. This supports the belief of many in the research field that shear and panels do not measure the same tenderness qualities of meat. A definite three-way interaction can be seen between 6 and 18 months of age where there is interaction between muscles, fat levels and muscle × fat level (Figure 5).

Table 5 shows a decrease in tenderness as animal age increased. The analysis of variance indicated that age had a great effect on tenderness ($P<.01$) (Table 6). All steaks from the six month old animals were

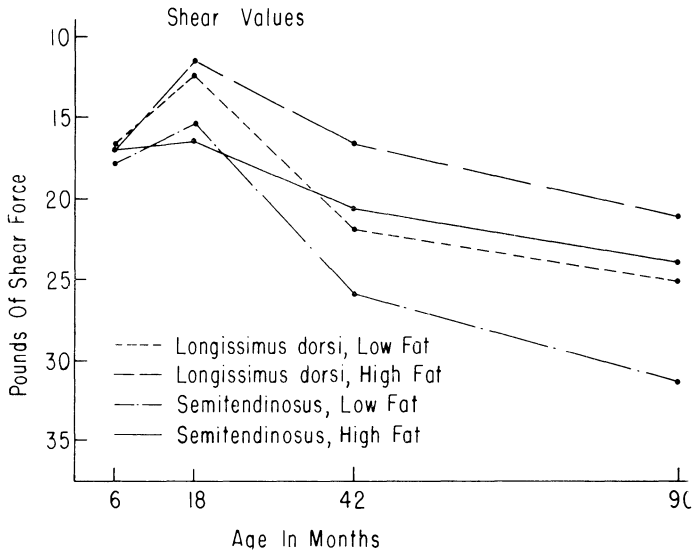

Figure 5. Shear values as influenced by animal age, muscle and level of fat.

Table 5—Age Means For Panel Tenderness[1,2]

Age in Months	6	18	42	90
Panel Score	6.1	5.5	4.0	3.8

[1]Combined values for *longissimus dorsi* and *semitendinosus* muscles including both fat levels.
[2]Rated on hedonic scale of 8 being extremely tender and 1 equaling extremely tough.

Table 6—Analysis Of Variance For Panel Tenderness

Source	df	M.S.	F-test	Sig.[1]
Total	79			
Age	3	12.33	9.63	.01
Fat Level	1	.09	.07	NS
Muscle	1	1.37	1.34	NS
Age × Muscle	3	3.40	3.33	.05
Age × Fat Level	3	2.69	2.10	NS
Muscle × Fat Level	1	.42	.41	NS
Age × Muscle × Fat Level	3	12.22	11.97	.01
Animal in Age × Fat Level	32	1.28		
Animal × Muscle in Age × Fat	32	1.02		

[1]NS – Not significant at 5 percent level of probability.
.05 – $P < .05$.
.01 – $P < .01$.

rated an average of 6.1 or "moderately tender" by the taste panel. At 18 months, tenderness was scored 5.5. This decrease did not agree with the shear value which proclaimed the 18 month steaks to be the most tender of the age spans used. Steaks from the 42 and 90 month old animals were rated approximately the same, "slightly tough."

The interaction of age and muscle was significant at the 5 percent level. The panel ratings for the steaks from the *longissimus dorsi* muscle indicated that 6 and 18 month age groups were comparable in tenderness (Table 7). A decrease of 1.5 points was noted for the span between 18 and 42 months. A slightly smaller decrease occurred between 42 and 90 months. The panel rated the *semitendinosus* muscle at 6 months as the most tender with a decrease of 1.3 points at 18 months and 1.5 points at 42 months.

Dividing each age group according to level of fat indicated a decline in tenderness between 6 and 42 months for the steaks in the low fat level group (Table 8). The panel scored the steaks from the 6 and 18 month high fat level groups comparable in tenderness with a sharp decline in tenderness occurring between 18, 42 and 90 months of age. The high fat level was slightly favored by the panel for the 18 and 42 month ages. In the 6 and 90 month age groups, the low fat level steaks were favored over the high fat level.

The steak groups pattern for tenderness is illustrated in Figure 6. The high fat level *longissimus dorsi* steaks were least tender of all steak groups at six months of age but were the most tender of the steak groups

Table 7—Age × Muscle Means For Panel Tenderness[1,2]

Age in Months	6	18	42	90	Avg.
Longissimus dorsi	5.9	6.1	4.6	3.9	5.1
Semitendinosus	6.3	5.0	3.5	3.7	4.6

[1]Averaged over both levels of fat.
[2]Rated on hedonic scale of 8 being extremely tender and 1 equaling extremely tough.

Table 8—Age × Fat Level Means For Panel Tenderness[1,2]

Age in Months	6	18	42	90	Avg.
Low Fat Level	6.4	5.4	4.0	4.1	4.9
High Fat Level	5.8	5.7	4.1	3.6	4.8

[1]Averaged over both muscles.
[2]Rated on hedonic scale; 8 being extremely tender and 1, extremely tough.

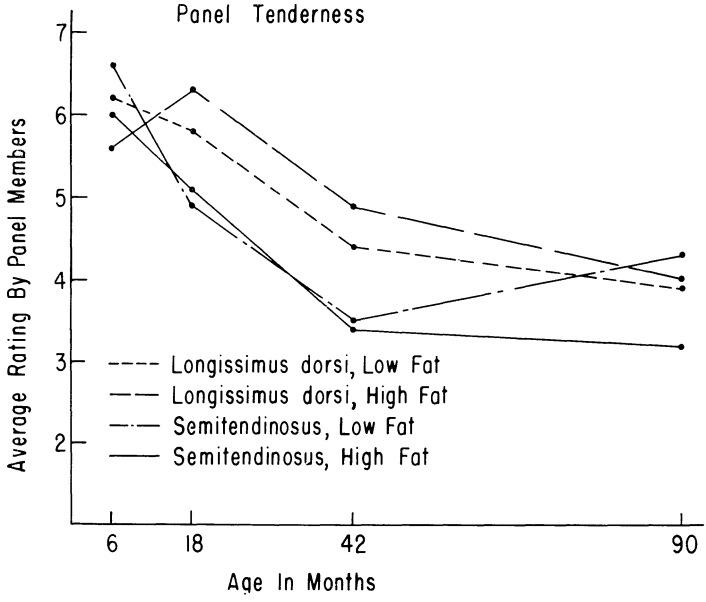

Figure 6. Panel tenderness as influenced by animal age, muscle and level of fat.

at 18 months. This was the only steak group which followed the pattern indicated by the shear force. The low level *longissimus dorsi* saw its greatest decrease in tenderness between 18 and 42 months. This steak group decreased in tenderness following the pattern of the over-all age means for panel tenderness. The low fat level *semitendinosus* steaks at six months were the most tender but decreased very sharply at 18 months and again at 42 months. These steaks deviated from the other steak groups by becoming more tender at 90 months of age. The high fat level *semitendinosus* became less tender as age increased up to 42 months and then appeared to level off.

Both the taste panel and the shear values indicated that the greatest decrease in tenderness occurred between 18 and 42 months of age regardless of whether the steaks were divided by age and muscle or age and level of fat.

Juiciness and Flavor

The taste panel rated the steaks from the forty animals all acceptable for juiciness. Average juiciness scores for individual steaks ranged from above "moderately dry" (42 month steak) to "very juicy" (90 month

steak). The two extreme ratings were for *longissimus dorsi* steaks of the high fat level group.

The analysis of variance for juiciness indicated a non-significant difference for the four age groups, two fat levels and two muscles (Table 9). The panel ratings were significant at the 5 percent level for the three-way interaction of age × muscle × fat level. The juiciness score for the low fat level for each muscle paralleled one another after the age of 18 months. In addition, the high level of fat for each muscle followed the same pattern after 18 months of age. At 18 months the high level of fat for each muscle was scored the most juicy. A reversal occurred between 18 and 42 months with the low fat level becoming the most juicy through the 90 month age. These differences may be observed by looking at Figure 7.

The flavor scores for the four age groups, two muscle and two fat levels, and the resulting interactions were not different enough to warrant significance according to the analysis of variance (Table 10, Figure 8).

The flavor for individual steaks ranged from "slightly desirable" (42 months) to "very desirable" (18 months). On the 8-point hedonic scale used by the panel for scoring even the lowest rating for flavor was above average. The amount of intramuscular fat did not seem to influence the judges' decision. The lowest rating for an individual steak was for a high fat level *longissimus dorsi* steak and the highest was for a *longissimus dorsi* steak in the low fat group.

No appreciable differences were noted in the fat level of the steaks by the panel. All steak groups contained less than eight percent fat except the *longissimus dorsi* high fat groups for 18 and 90 months of age.

Table 9—Analysis Of Variance For Panel Juiciness

Source	df	M.S.	F-test	Sig.[1]
Total	79			
Age	3	.11	.17	NS
Fat Level	1	.03	.06	NS
Muscle	1	.89	1.64	NS
Age × Muscle	3	.36	.66	NS
Age × Fat Level	3	.16	.27	NS
Muscle × Fat Level	1	.00	.00	NS
Age × Muscle × Fat Level	3	2.04	3.75	.05
Animal in Age × Fat Level	32	.61		
Animal × Muscle in Age × Fat	32	.55		

[1]NS – Not significant at 5 percent level of probability.
.05 – $P < .05$.

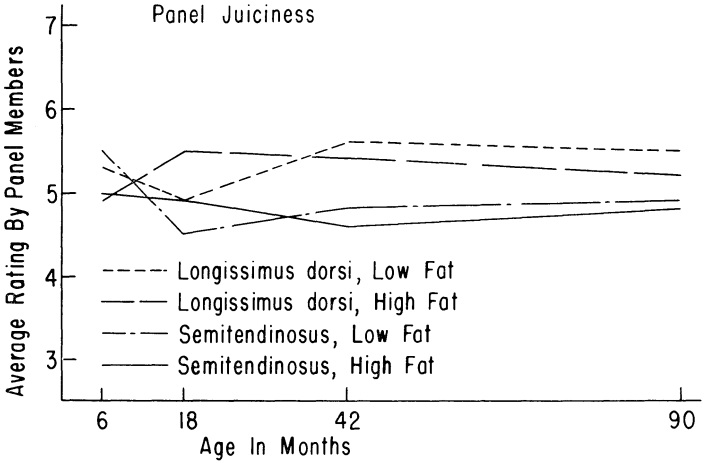

Figure 7. Panel juiciness as influenced by animal age, muscle and level of fat.

Table 10—Analysis Of Variance For Panel Flavor

Source	df	M.S.	F-test	Sig.[1]
Total	79			
Age	3	.42	1.95	NS
Fat Level	1	.13	.62	NS
Muscle	1	.18	1.11	NS
Age × Muscle	3	.08	.49	NS
Age × Fat Level	3	.05	.22	NS
Muscle × Fat Level	1	.19	1.18	NS
Age × Muscle × Fat Level	3	.40	2.52	NS
Animal in Age × Fat Level	32	.21		
Animal × Muscle in Age × Fat	32	.19		

[1]NS — Not significant at 5 percent level of probability.

Meat flavor is very difficult for any panel to evaluate satisfactorily. Since these steaks were not aged, many of the panel members may have considered the flavor as mild for all age groups. Therefore, the lack of any strong flavor may have caused the panel members to rate all steaks between "slightly desirable" and "very desirable" on the hedonic scale.

The proximate analysis was completed because of the relationship of fat and moisture to the organoleptic qualities of juiciness and flavor. The analysis of variance for ether extract indicated all variables highly significant with the exception of age × fat level interaction which was significant at the five percent level (Table 11). The percent moisture of the raw product was highly significant for all variables except age × fat level (Table 12).

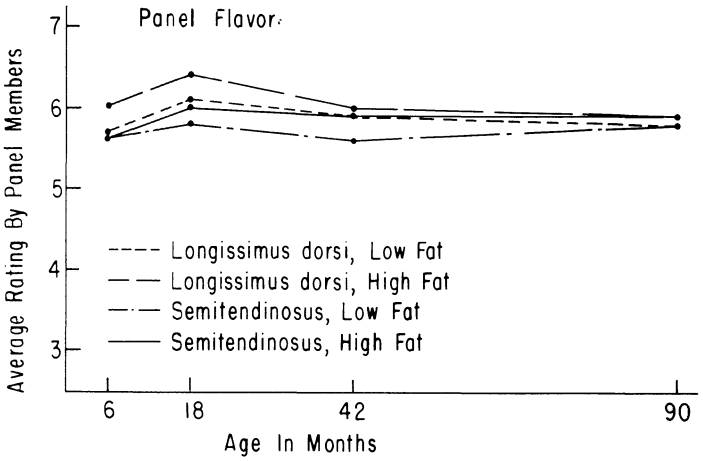

Figure 8. Panel flavor as influenced by animal age, muscle and level of fat.

Table 11—Analysis Of Variance For Percent Ether Extract

Source	df	M.S.	F-test	Sig.[1]
Total	79			
Age	3	54.040	37.01	.01
Fat Level	1	232.903	159.52	.01
Muscle	1	52.650	65.32	.01
Age × Muscle	3	11.104	13.78	.01
Age × Fat Level	3	5.002	3.43	.05
Muscle × Fat Level	1	14.878	18.46	.01
Age × Muscle × Fat Level	3	4.778	5.93	.01
Animal in Age × Fat Level	32	1.460		
Animal × Muscle in Age × Fat	32	.806		

[1].05 – P<.05.
.01 – P<.01.

The analysis of variance for the combined moisture and ether extract indicated no significant difference except level of fat which was significant at the one percent level (Table 13). In the combined percentages there was less than one percent difference in the means for the four age groups averaged over muscle and fat level (Table 14). Dividing the ages into fat level groups, there was less than two percent difference between the lowest and highest scores (Table 15).

If there were differences in juiciness and flavor the panel did not detect it. The role of moisture and fat content on juiciness and flavor

Table 12—Analysis Of Variance For Percent Moisture

Source	df	M.S.	F-test	Sig.[1]
Total	79			
Age	3	51.092	37.16	.01
Fat Level	1	109.278	79.47	.01
Muscle	1	77.028	75.81	.01
Age × Muscle	3	6.574	6.47	.01
Age × Fat Level	3	2.656	1.93	NS
Muscle × Fat Level	1	9.453	9.30	.01
Age × Muscle × Fat Level	3	5.377	5.29	.01
Animal in Age × Fat Level	32	1.375		
Animal × Muscle in Age × Fat	32	1.016		

[1]NS — Not significant at 5 percent level of probability.
.01 — $P < .01$.

Table 13—Analysis Of Variance Of The Combined Values For Percent Ether Extract And Moisture

Source	df	M.S.	F-test	Sig.[1]
Total	79			
Age	3	1.420	1.01	NS
Fat Level	1	23.113	16.46	.01
Muscle	1	2.312	3.44	NS
Age × Muscle	3	.685	1.02	NS
Age × Fat Level	3	.606	.43	NS
Muscle × Fat Level	1	.613	.91	NS
Age × Muscle × Fat Level	3	1.184	1.76	NS
Animal in Age × Fat Level	32	1.404		
Animal × Muscle in Age × Fat	32	.672		

[1]NS — Not significant at 5 percent level of probability.
.01 — $P < .01$.

Table 14—Age Means For Combined Values Of Percent Ether Extract And Percent Moisture[1]

Age in Months	6	18	42	90
Ether extract	77.0	77.3	76.8	76.8

[1]Values for the *longissimus dorsi* and *semitendinosus* muscles including both fat levels.

Table 15—Age × Fat Level Means For Combined Values Of Percent Ether Extract And Percent Moisture[1]

Age in Months	6	18	42	90	Avg.
Low	76.6	76.9	76.1	76.1	76.3
High	77.3	77.8	77.4	77.5	77.5

[1]Averaged over both muscles.

of a steak is not clearly understood. The taste panel could not discriminate between the apparent differences that existed in the moisture content or the fat content of the steak groups. It may be that moisture and fat content are confounded so that the sum of the effects was measured and the influence of one could not be separated. The significant level of fat for the combined moisture and fat percentages did not influence the scores appreciably for juiciness and flavor.

Summary

This publication reports results of a study made to determine the influence of animal age, variation of muscles and fat levels within muscles on the tenderness, juiciness and flavor of meat.

Cattle of four different age groups, 6, 18, 42 and 90 months, were used. The *longissimus dorsi* and *semitendinosus* muscles of forty carcasses were used for the study.

Age was an influencing variable for tenderness. Results indicated steaks from the 18 month-old cattle were the most tender for both muscles. The *longissimus dorsi* steaks were slightly more tender than the *semitendinosus* steaks but not significantly.

The high fat level *longissimus dorsi* was the most tender followed by the high fat level *semitendinosus,* the low fat level *longissimus dorsi* and the low fat level *semitendinosus.*

Fat within the muscle was relatively unimportant in steaks from animals under 20 months of age but it did play a more significant role in the tenderness, juiciness and flavor of steaks from older animals.

6-65/2½M