October 1976

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CHARACTERIZATION OF BIOLOGICAL TYPES OF CATTLE III. CARCASS COMPOSITION, QUALITY AND PALATABILITY[1,2]

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SUMMARY

Composition and quality characteristics of 1,121 steer carcasses obtained after mating Hereford and Angus cows to Hereford, Angus, Jersey, South Devon, Limousin, Charolais and Simmental sires were compared at a (1) constant age, (2) constant weight, and (3) constant percentage of fat in the *longissimus* muscle. Taste panel evaluation was made on a subsample of 496 carcasses. Growth rate of retail product, fat trim and bone differed significantly among sire breed groups. Breed group differences in relative proportions of retail product, fat trim and bone were largest when compared at a constant carcass weight and smallest when compared at equal fat in the *longissimus*. There was a positive association between growth rate of breed groups and percentage of retail product or bone. A negative association was observed between growth rate of breed groups and percentage of fat trim. A negative association between growth rate and percentage of fat in the *longissimus* resulted in breed groups attaining the same percentage of fat in the *longissimus* at significantly different average carcass weights. Conformation and marbling attributes of quality grade differed significantly among breed groups, but color, texture and firmness of lean and maturity differences were small. Tenderness differences among breed groups were small with all breed groups well above minimum levels of acceptance. Breed group means for taste panel tenderness and marbling were positively associated. Within breed groups, the desirable influence of increased marbling associated with time on feed was essentially counteracted by the undesirable influence of increased age. Breed groups did not differ significantly in flavor or juiciness scores.
(Key Words: Cattle, Breeds, Carcass, Composition, Quality, Palatability.)

INTRODUCTION

Characterization of biological attributes of breeds or breed crosses helps producers use genetic resources wisely to increase production efficiency or to meet changes in market demand because genetic improvement involves effective use of genetic variation between as well as within breeds. This study involved evaluation of carcasses from 14 breed combinations and was part of a germ plasm evaluation program at the U.S. Meat Animal Research Center, Clay Center, Nebraska. The breed groups are not a random sample of all breeds nor do they depict total variation to be expected in the cattle population. Nevertheless, the breed groups evaluated are expected to provide indications of genetic differences associated with breeds in general as well as some insight to genetic differences within breeds.

MATERIALS AND METHODS

Design and production details for Cycle I of the cattle germ plasm evaluation program at the U.S. Meat Animal Research Center were reported previously by Smith *et al.*, 1976a,b. Basically, Cycle I involved breeding Hereford and Angus cows by artificial insemination to

[1]Published as Paper No. 3991 Journal Series, Nebraska Agricultural Experiment Station, Lincoln and Contribution No. 495, Dept. of Animal Science and Industry, Kansas Agricultural Experiment Station, Manhattan.

[2]The authors are grateful for assistance of the Standardization Branch, A.M.S., U.S.D.A., especially C. E. Murphey, in grading carcasses.

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Hereford, Angus, Jersey, South Devon, Limousin, Charolais and Simmental sires to produce three calf crops (1970, 1971 and 1972). All male calves were castrated within 24 hr of birth. Calves were weaned in October or November at approximately 215 days of age. Following weaning and a 25- to 30-day adjustment period, steers were fed *ad libitum* on a corn silage and concentrate ration that averaged 2.8 Mcal metabolizable energy per kilogram for the feeding period.

Each year steers in breed of sire by breed of dam groups were stratified by age and one-third were randomly designated for slaughter at one of three slaughter dates about 1 month apart. Slaughter at three dates provided a measure of change in carcass characteristics during the latter part of the feeding period. Number of days on feed for the slaughter groups were 190, 218 and 246 days for 1970 calves; 169, 211 and 253 days for 1971 calves; and 194, 226 and 253 days for 1972 calves. Each slaughter group was a random sample, and steers thus, had the same expected genetic merit with approximately the same average birth date, but within groups, varied in age about 45 days.

After a final weight without feed for 12 hr but with access to water, steers were transported to a commercial plant and slaughtered the next morning. Carcass data were obtained after a 24-hr chill. Carcasses were evaluated for conformation, maturity, marbling, color, texture, firmness and quality grade according to specifications outlined by U.S.D.A. (1965). *Longissimus* muscle area and external fat thickness were measured at the 12th rib. The right side of each carcass was transported to Kansas State University. Three 32 mm steaks were cut from the wholesale rib at the 10, 11 and 12th rib locations 3 to 4 days postmortem and frozen for later palatability and chemical evaluations. Carcass sides were then fabricated into retail cuts within 1 to 10 days after removal of the rib steaks. The kidney knob (including kidney) and pelvic fat were removed and included as part of total fat trim. The round, loin, rib and chuck were trimmed to an average of 8 mm external fat and then processed into roast and steak meat and lean trim. Except for dorsal and transverse spinous processes remaining in short loin roasts and dorsal spinous processes and rib bones in rib roasts, all cuts were boneless. No more than 8 mm fat was left on any surface. Lean from the flank, plate, brisket and shank were added to the lean trim. Lean from all wholesale cuts was trimmed to contain 25% fat. The weight of external fat trim, roasts, lean trim, total fat trim and bone was determined individually for wholesale cuts. Chemical analysis of the lean trim in each carcass was used to adjust total lean trim to a 25% fat basis. The sum of roast and steak meat plus lean trim was called retail product.

In the 1971 calf crop the 9-10-11th rib cut from the left side of each carcass was removed according to procedures outlined by Hankins and Howe (1946). Ether extract and moisture determinations of the combined soft tissues were made according to A.O.A.C. (1965) methods. Protein was determined by difference less 1% for ash.

The 12th rib steak from each side was used to determine intramuscular fat of the *longissimus* muscle. The 11th rib steak was thawed overnight at 2 to 4 C, and oven broiled at 177 C in a preheated rotary oven to an internal temperature of 65 C. After cooling approximately 30 min, 1.27 cm cores were removed. Eight cores from each 11th rib steak were subjected to the Warner-Bratzler shear test. These determinations were made 2 to 4 weeks after each group was slaughtered. Tenth rib steaks for taste panel evaluation were thawed, cooked and cored like Warner-Bratzler shear tests. Six cores were served to a six-member taste panel who scored them for tenderness, juiciness, flavor and overall acceptability on a 9-point scale. Taste panel evaluations began each year about 3 months after the first slaughter and continued about 4 months. Each week, 21 evaluations were made and selection of carcasses to be evaluated was designed to balance breed groups and slaughter dates over the entire period of evaluation.

Least squares analyses using a fixed model procedure and program as outlined by Harvey (1972) were performed on composition and quality traits from 1,121 steers and on taste panel data from the sub-set of 496 carcasses. The model included main effects of breed of sire, breed of dam, year, age of dam, and the two-way interactions among breed of sire, breed of dam and year. In addition, linear regression of traits on differences in age at the start of the feeding period (associated with differences in birth date) and regression on days fed were fitted for breed of sire by breed of dam subclasses. A preliminary analysis indicated no significant curvilinear regression of traits on days fed. Genetic merit of animals was expected to be randomly associated with starting age and with animals in each of the three slaughter groups within years.

The subclass regressions provide a method of adjusting breed group means for three alternative endpoints: (1) constant age, (2) constant carcass weight, and (3) constant percentage of fat in the *longissimus* muscle, all without bias from genetic differences between or within breed groups. The least squares means were adjusted to the average age at start of feeding of 240 days and to the average of 217 days fed using the model outlined previously. These age constant least squares means were then adjusted to a hot carcass weight of 288 kg by the following procedure. Adjusted mean = $\overline{Y}_{ij}$ + $D_i b_{2ij}$, where $\overline{Y}_{ij}$ is the age constant, least squares mean and b_{2ij} the subclass regression on days fed for the ith breed group and the jth trait. D_i was the calculated number of days above or below 217 that the ith breed group would have to be fed to reach 288 kg carcass weight; $D_i = (288-\overline{W}_i)/b_{2iw}$, where $\overline{W}_i$ is the least squares mean and b_{2iw} is the regression of hot carcass weight on days fed for the ith breed group. Means adjusted in this way estimate what would have been obtained if all animals in a breed group had been fed fewer or more days until the average of the breed group reached a hot carcass weight of 288 kilograms. Similarly, age constant least squares means were adjusted to 5% fat in the *longissimus* muscle. Here, $D_i = (5.0 - \overline{L}_i)/b_{2il}$, and $\overline{L}_i$ and b_{2il} are the least squares mean and the subclass regression on days fed for % *longissimus* fat of the ith breed group.

RESULTS AND DISCUSSION

Carcass Composition

Analysis of Variance. Results of analysis of variance among carcass composition traits are shown in table 1. Data obtained on one side were doubled so mean squares are on a whole carcass basis. Breed of sire was a highly significant source of variation for all traits. Steers from Hereford and Angus dams did not differ significantly in weight of retail product or roasts but differed significantly for measures of fatness and bone. The significant breed of sire by breed of dam interaction resulted primarily from heterosis of Hereford-Angus crossbreds and to some extent by interaction in South Devon and Limousin subclasses. Each year a different set of sires was used to represent the sire breeds although some sires were repeated, especially in Limousin, Simmental and South Devon breeds (Smith *et al.*, 1976b). Thus significance of breed of sire by year interactions may be due to differences in sets of sires as well as differential response of sire breeds over the years. Interactions were small compared with main effects of sire breed and year. Average regression coefficients of traits on differences in starting age (b_1) and days fed (b_2) were significantly different from zero, but differences among regression coefficients for breed of sire, breed of dam, or breed of sire × breed of dam subclasses generally were not significant.

Alternative Endpoints. Least squares means adjusted to 240 days of age at start and 217 days on feed are shown in table 2 and reflect differences in average growth rates for various traits. Means adjusted to an average hot carcass weight of 288 kg are given in table 3. A 288 kg carcass weight was selected because it approximated the average of Hereford-Angus crossbreds which were considered a useful base for comparison. A hot carcass of 288 kg corresponds to a live weight of about 454 kilograms. Means adjusted to 5% fat in the *longissimus* muscle are shown in table 4. In these data 5% *longissimus* fat was equivalent to a marbling score of average Small, which slightly exceeds minimal requirements for U.S.D.A. Choice grade. Garrett and Hinman (1971) reported 4.3% *longissimus* fat as the average for Small marbling. Average carcass composition of sire breed groups at alternative endpoints is presented in table 5.

Heterosis in Hereford-Angus Crosses. A major part of the significant breed of sire by breed of dam interaction (table 1) was associated with heterosis of Hereford-Angus crossbreds. Heterosis is evaluated by comparing the average of straightbred Hereford and Angus steers with the average of reciprocal crossbreds (columns 1 and 2 in tables 2, 3 and 4). Heterosis was significant for all traits listed in table 2 except *longissimus* fat. No heterosis was apparent when traits were adjusted to a common carcass weight (table 3), indicating that heterosis was a generalized increase in growth rather than favoring one type of tissue like fat, lean or bone. Heterosis is also expected in crosses of Jersey, South Devon, Limousin, Charolais and Simmental sires with Hereford and Angus dams. Therefore, comparisons of Hereford and Angus sires with other sire breeds

TABLE 1. ANALYSIS OF VARIANCE OF CARCASS COMPOSITION

		Mean squares												
				Carcass weight								*Longissimus*		
Source	df	Slaughter weight kg	Hide weight kg	Hot kg	Cold kg	Bone kg	Retail product kg	Roasts kg	Fat trim kg	Kidney fat kg	Fat thickness mm	Fat %	Area cm^2	Yield grade
Breed of sire (BS)	6	77379**	1222**	29341**	28644**	1334**	40155**	10456**	6381**	414**	1026**	133**	4534**	25.4**
Breed of dam (BD)	1	118	1737**	1825	2184	425**	80	8	5818**	167**	793**	162**	450**	5.0**
Year (Y)	2	198038**	1302**	144300**	128816**	670**	32327**	9181**	64498**	999**	2598**	292**	354**	33.8**
Age of dam	3	58167**	266**	32965**	30930**	180**	7194**	2691**	6099**	195**	55*	5	561**	3.6**
BS X BD	6	4045**	24	1941**	2109**	31**	916**	256**	573**	17*	44*	2	125*	.6
BS X Y	12	3741**	21	1861**	1877**	19*	709**	221**	811**	22**	38*	6*	138**	1.4**
BD X Y	2	361	8	411	194	14	815*	124	794**	14	135*	6	114	2.3**
b_1 (starting age)	1	106031**	301**	35786**	52753**	249**	13986**	5280**	9148**	277**	135**	21**	1216**	5.6**
b_1 X BS	6	813	3	590	452	11	256	68	55	7	14	11**	67	.3
b_1 X BD	1	216	0	7	7	2	66	9	17	0	38	1	2	.3
b_2 (days fed)	1	587234**	2194**	219716**	287054**	898**	67791**	21189**	60246**	1753**	2668**	680**	1192**	50.4**
b_2 X BS	6	1331	34*	636	761	18	635*	150	175	4	10	12**	59	.2
b_2 X BD	1	420	68*	229	144	9	272	53	56	36*	2	1	2	.0
b_2 X BS X BD	6	1287	9	982	1019	12	482	142	113	5	30	1	20	.2
Residual	1066	1358	15	624	596	10	268	78	171	7	17	3	60	.4

*$P<.05$.

**$P<.01$.

TABLE 2. LEAST SQUARES MEANS ADJUSTED TO A STARTING AGE OF 240 DAYS AND 217 DAYS ON FEED AND STANDARD DEVIATION WITHIN BREED GROUPS

		Breed groups[a]								
Trait	Dam breed	H.H. A.A.	A.H. H.A.	J.H. J.A.	SD.H. SD.A.	L.H. L.A.	C.H. C.A.	S.H. S.A.	Avg	SD[b]
No. of animals	H	69	97	53	44	82	78	87	510	
	A	85	113	81	50	95	99	88	611	
Slaughter weight, kg	H	440	455	434	459	458	496	490	462	
	A	439	453	429	470	462	491	483	461	
	Avg	440	454	432	465	460	493	486	461	36.8
Hide weight, kg	H	39.4	36.3	31.7	35.7	35.9	39.1	42.2	37.2	
	A	32.7	37.0	29.5	33.8	34.0	36.3	38.3	34.5	
	Avg	36.0	36.6	30.6	34.8	35.0	37.7	40.2	35.9	3.9
Hot carcass weight, kg	H	276.5	289.0	269.9	292.4	292.7	313.0	305.5	291.3	
	A	280.6	288.7	268.4	302.3	298.8	314.0	305.4	294.0	
	Avg	278.6	288.9	269.1	297.4	295.7	313.5	305.4	292.7	25.0
Cold carcass weight, kg	H	266.7	279.4	261.0	282.8	282.5	303.2	295.9	281.6	
	A	270.9	279.3	259.4	293.0	289.8	304.3	295.5	284.6	
	Avg	268.8	279.4	260.2	287.9	286.2	303.8	295.7	283.1	24.4
Bone, kg	H	33.8	33.9	33.2	35.5	36.0	40.4	40.7	36.2	
	A	31.7	32.9	31.4	35.5	35.8	38.5	38.5	34.9	
	Avg	32.7	33.4	32.3	35.5	35.9	39.5	39.6	35.6	3.2
Retail product, kg	H	179.8	184.6	169.8	189.1	203.1	218.0	210.1	193.5	
	A	177.6	181.5	167.8	196.9	207.0	214.4	205.1	192.9	
	Avg	178.7	183.1	168.8	193.0	205.1	216.2	207.6	193.2	16.4
Roasts, kg	H	98.9	101.4	93.4	103.5	110.1	118.5	114.2	105.7	
	A	97.7	100.5	92.4	107.0	112.6	116.6	112.0	105.5	
	Avg	98.3	100.9	92.9	105.3	111.4	117.6	113.1	105.6	8.8
Fat trim, kg	H	53.1	61.0	58.0	58.1	43.5	44.8	45.2	51.9	
	A	61.6	64.8	60.2	60.7	47.0	51.4	51.9	56.8	
	Avg	57.3	62.9	59.1	59.4	45.3	48.1	48.5	54.4	13.1
Kidney and pelvic fat, kg	H	8.3	10.2	15.0	12.2	10.4	11.1	10.7	11.1	
	A	10.3	9.5	14.9	12.8	11.7	12.0	12.4	11.9	
	Avg	9.3	9.9	15.0	12.5	11.0	11.6	11.5	11.5	2.6
Fat thickness, mm	H	13.1	16.0	10.6	11.8	10.2	8.9	9.3	11.4	
	A	16.8	16.9	12.9	13.1	10.8	10.8	11.0	13.2	
	Avg	15.0	16.5	11.8	12.4	10.5	9.9	10.1	12.3	4.1
Longissimus fat, %	H	5.0	6.2	6.0	5.2	3.6	4.3	4.4	5.0	
	A	6.9	5.7	7.4	5.9	4.3	5.1	5.1	5.8	
	Avg	6.0	6.0	6.7	5.6	3.9	4.7	4.8	5.4	1.7
Longissimus area, cm^2	H	68.8	72.0	68.1	75.8	81.8	80.4	78.6	74.8	
	A	70.6	71.7	68.8	76.1	83.2	83.9	78.7	76.1	
	Avg	69.6	71.9	68.5	75.0	82.5	82.2	78.6	75.5	7.7
Yield grade	H	3.1	3.3	3.4	3.1	2.4	2.4	2.5	2.9	
	A	3.4	3.4	3.4	3.1	2.5	2.6	2.7	3.0	
	Avg	3.2	3.4	3.4	3.1	2.4	2.5	2.6	3.0	.6
SE coefficient[b] × 100	H	12.2	10.4	14.9	15.4	12.1	11.6	11.4	4.8	
	A	11.4	9.8	12.7	14.6	11.4	10.6	10.5	4.4	
	Avg	8.4	7.2	10.3	10.5	8.8	7.9	7.9	3.3	

[a]H = Hereford, A = Angus, J = Jersey, SD = South Devon, L = Limousin, C = Charolais, S = Simmental. Breed of sire is given first and breed of dam is given second.

[b]Standard error of a least squares mean can be determined by multiplying the SE coefficient × standard deviation of a trait, e.g., SE of slaughter weight for H.H. = .122 × 36.8 = 4.5.

should be based on the Hereford-Angus crossbred groups, and not the straightbreds.

Slaughter and Hide Weight. Slaughter weight was the average of two weights at the feedlot

TABLE 3. LEAST SQUARES MEANS ADJUSTED TO A HOT CARCASS WEIGHT OF 288 KILOGRAMS

		Breed groups[a]								
Trait	Dam breed	H.H. A.A.	A.H. H.A.	J.H. J.A.	SD.H. SD.A.	L.H. L.A.	C.H. C.A.	S.H. S.A.	Avg	SD[b]
Estimated days on feed	H	236	216	247	210	207	172	192	211	
	A	232	216	267	190	200	178	194	211	
	Avg	234	216	257	200	203	175	193	211	
Slaughter weight, kg	H	457	454	458	453	450	458	465	456	
	A	449	452	461	450	447	455	457	453	
	Avg	453	453	460	451	449	456	461	455	36.8
Hide weight, kg	H	40.8	36.2	33.2	35.2	35.5	35.7	40.3	36.7	
	A	33.2	37.0	30.1	32.7	33.3	34.5	36.4	33.9	
	Avg	37.0	36.6	31.6	34.0	34.4	35.1	38.3	35.3	3.9
Cold carcass weight, kg	H	278.3	278.4	278.4	278.5	277.8	278.7	278.3	278.3	
	A	278.0	278.6	278.4	279.1	278.8	278.7	277.5	278.4	
	Avg	278.1	278.5	278.4	278.8	278.3	278.7	277.9	278.4	24.4
Bone, kg	H	34.2	33.8	34.2	35.3	35.8	38.4	39.4	35.9	
	A	31.9	32.9	32.9	34.9	35.3	37.1	37.0	34.6	
	Avg	33.0	33.4	33.5	35.1	35.5	37.7	38.2	35.2	3.2
Retail product, kg	H	185.0	184.0	176.9	187.0	201.0	203.7	199.9	191.1	
	A	180.4	181.2	175.3	191.8	201.7	200.4	194.8	189.4	
	Avg	182.7	182.6	176.1	189.4	201.4	202.1	197.3	190.2	16.4
Roasts, kg	H	102.0	101.1	97.8	102.3	109.2	111.1	108.7	104.6	
	A	99.4	100.3	97.1	103.8	109.8	109.0	106.6	103.7	
	Avg	100.7	100.7	97.4	103.1	109.5	110.0	107.6	104.1	8.8
Fat trim, kg	H	59.1	60.6	67.3	56.3	41.0	36.5	38.9	51.4	
	A	65.8	64.5	70.2	52.5	41.8	41.1	45.7	54.5	
	Avg	62.5	62.5	68.8	54.4	41.4	38.8	42.3	53.0	13.1
Kidney and pelvic fat, kg	H	9.1	10.2	16.1	12.0	9.8	9.4	9.7	10.9	
	A	10.9	9.4	17.4	11.0	10.8	9.9	11.1	11.5	
	Avg	10.0	9.8	16.8	11.5	10.3	9.6	10.4	11.2	2.6
Fat thickness, mm	H	14.3	15.9	13.3	11.5	9.6	7.1	8.3	11.4	
	A	17.6	16.8	14.1	11.1	9.8	8.2	9.9	12.5	
	Avg	16.0	16.4	13.7	11.3	9.7	7.6	9.1	12.0	4.1
Longissimus fat, %	H	5.5	6.2	7.1	5.0	3.4	3.1	4.0	4.9	
	A	7.6	5.7	9.3	5.2	3.8	4.1	4.6	5.8	
	Avg	6.6	6.0	8.2	5.1	3.6	3.6	4.3	5.3	1.7
Longissimus area, cm^2	H	69.7	71.9	68.5	73.8	81.6	77.9	77.3	74.4	
	A	71.2	71.7	70.5	76.0	82.5	80.8	78.1	75.8	
	Avg	70.5	71.8	69.5	74.9	82.1	79.4	77.7	75.1	7.7
Yield grade	H	3.2	3.3	3.6	3.1	2.3	2.2	2.3	2.9	
	A	3.5	3.4	3.7	2.8	2.4	2.3	2.5	2.9	
	Avg	3.4	3.4	3.7	3.0	2.3	2.2	2.4	2.9	.6
SE coefficient[b] × 100	H	14.7	10.4	20.7	15.8	12.8	21.6	15.1		
	A	13.0	9.8	23.7	19.3	13.3	18.5	13.9		
	Avg	9.8	7.2	16.3	12.2	9.6	14.2	10.4		

[a] H = Hereford, A = Angus, J = Jersey, SD = South Devon, L = Limousin, C = Charolais, S = Simmental. Breed of sire is given first and breed of dam is given second.

[b] Standard error of a least squares mean can be determined by multiplying the SE coefficient × standard deviation of a trait, e.g., SE of slaughter weight for H.H. = .147 × 36.8 = 5.4.

obtained 24 hr apart and shrunk 4% to provide a measure of market weight.

Hide weights adjusted for differences in carcass weight (table 3) were heaviest in

TABLE 4. LEAST SQUARES MEANS ADJUSTED TO 5% FAT IN THE *LONGISSIMUS* MUSCLE

Trait	Dam breed	Breed groups[a] H.H. A.A.	A.H. H.A.	J.H. J.A.	SD.H. SD.A.	L.H. L.A.	C.H. C.A.	S.H. S.A.	Avg	SD[b]
Estimated days on feed	H	216	186	191	212	284	242	256	227	
	A	180	181	156	184	244	213	211	196	
	Avg	198	184	174	198	264	228	233	211	
Slaughter weight, kg	H	440	423	414	454	506	517	530	469	
	A	415	421	390	445	486	488	475	446	
	Avg	427	422	402	450	496	502	503	457	36.8
Hide weight, kg	H	39.3	34.8	30.4	35.3	38.7	41.1	45.2	37.8	
	A	31.1	35.8	28.8	32.5	35.2	36.1	37.1	33.8	
	Avg	35.2	35.3	29.6	33.9	37.0	38.6	41.2	35.8	3.9
Hot carcass weight, kg	H	276.1	265.0	254.2	288.7	323.3	327.0	333.4	295.4	
	A	261.9	264.6	244.4	284.8	315.6	311.6	300.6	283.4	
	Avg	269.0	264.8	249.3	286.7	319.4	319.3	317.0	289.4	25.0
Cold carcass weight, kg	H	266.2	256.0	246.0	279.2	313.5	316.9	324.0	286.0	
	A	253.2	254.9	236.2	276.0	307.1	302.0	290.5	274.3	
	Avg	259.7	255.5	241.1	277.6	310.3	309.4	307.3	280.1	24.4
Bone, kg	H	33.7	32.2	32.4	35.3	37.1	41.6	42.7	36.4	
	A	31.3	32.2	29.6	34.7	36.6	38.4	38.1	34.4	
	Avg	32.5	32.2	31.0	35.0	36.8	40.0	40.4	35.4	3.2
Retail product, kg	H	179.6	171.7	163.6	187.3	216.5	226.0	226.2	195.8	
	A	170.8	171.1	158.7	190.6	215.3	213.1	202.3	188.8	
	Avg	175.2	171.4	161.2	189.0	215.9	219.5	214.3	192.3	16.4
Roasts, kg	H	98.8	94.2	89.7	102.5	116.3	122.6	122.9	106.7	
	A	93.4	94.4	86.7	103.1	117.1	115.9	110.5	103.0	
	Avg	96.1	94.3	88.2	102.8	116.7	119.3	116.7	104.9	8.8
Fat trim, kg	H	52.9	52.1	50.0	56.6	59.8	49.4	55.0	53.7	
	A	51.1	51.6	47.9	50.6	55.2	50.5	50.2	51.0	
	Avg	52.0	51.9	48.9	53.6	57.5	49.9	52.6	52.3	13.1
Kidney and pelvic fat, kg	H	8.3	9.1	14.0	12.0	14.3	12.0	12.2	11.7	
	A	8.8	7.5	11.8	10.6	13.1	11.8	12.1	10.8	
	Avg	8.6	8.3	12.9	11.3	13.7	11.9	12.1	11.3	2.6
Fat thickness, mm	H	13.1	13.7	8.4	11.5	13.5	10.0	10.9	11.6	
	A	14.8	13.8	11.3	10.7	12.5	10.6	10.7	12.1	
	Avg	13.9	13.8	9.9	11.1	13.0	10.3	10.8	11.8	4.1
Longissimus area, cm^2	H	68.8	69.4	67.9	73.8	82.9	81.7	80.6	75.0	
	A	68.6	69.9	66.8	75.9	84.2	83.7	78.5	75.4	
	Avg	68.7	69.7	67.4	74.9	83.6	82.7	79.6	75.2	7.7
Yield grade	H	3.1	3.1	3.1	3.1	3.0	2.6	2.8	3.0	
	A	3.2	3.1	3.1	2.8	2.8	2.5	2.7	2.9	
	Avg	3.2	3.1	3.1	2.9	2.9	2.6	2.7	2.9	.6
SE coefficient[b] × 100	H	12.3	15.1	19.4	15.7	29.6	15.7	19.4	4.8	
	A	19.0	16.3	27.6	21.3	15.6	10.6	10.8	5.9	
	Avg	10.0	11.1	17.1	12.2	16.0	8.4	9.1	3.6	

[a]H = Hereford, A = Angus, J = Jersey, SD = South Devon, L = Limousin, C = Charolais, S = Simmental. Breed of sire is given first and breed of dam is given second.

[b]Standard error of a least squares mean can be determined by multiplying the SE coefficient × standard deviation of a trait, e.g., SE of slaughter weight for H.H. = .123 × 36.8 = 4.5.

TABLE 5. AVERAGE COMPOSITION AT ALTERNATIVE ENDPOINTS

Trait	Endpoint[b]	H.H. A.A.	A.H. H.A.	J.H. J.A.	SD.H. SD.A.	L.H. L.A.	C.H. C.A.	S.H. S.A.
		Breed groups[a]						
Dressed yield, %[c]	Age	63.3	63.6	62.4	64.0	64.3	63.5	62.8
	Wt	63.6	63.6	62.7	63.8	64.2	63.1	62.4
	Fat	62.9	62.7	62.0	63.8	64.4	63.6	63.1
Bone, %[d]	Age	12.2	12.0	12.4	12.3	12.5	13.0	13.4
	Wt	11.9	12.0	12.0	12.6	12.8	13.6	13.8
	Fat	12.5	12.6	12.9	12.6	11.9	12.9	13.1
Retail product, %[d]	Age	66.5	65.5	64.9	67.0	71.7	71.2	70.2
	Wt	65.7	65.6	63.3	67.9	72.4	72.5	71.0
	Fat	67.5	67.1	66.9	68.1	69.6	70.9	69.7
Roasts, %[d]	Age	36.6	36.1	35.7	36.6	38.9	38.7	38.2
	Wt	36.2	36.2	35.0	37.0	39.3	39.5	38.7
	Fat	37.0	36.9	36.6	37.0	37.6	38.5	38.0
Fat trim, %[d]	Age	21.3	22.5	22.7	20.6	15.8	15.8	16.4
	Wt	22.5	22.4	24.7	19.5	14.9	13.9	15.2
	Fat	20.2	20.3	20.3	19.2	18.5	16.2	17.2
Kidney and pelvic fat, %[d]	Age	3.5	3.5	5.7	4.3	3.8	3.8	3.9
	Wt	3.6	3.5	6.0	4.1	3.7	3.5	3.7
	Fat	3.3	3.2	5.3	4.1	4.4	3.8	4.0

[a]H = Hereford, A = Angus, J = Jersey, SD = South Devon, L = Limousin, C = Charolais, S = Simmental. Breed of sire is given first and breed of dam is given second.

[b]Age = 457 days of age, Wt = 288 kg hot carcass weight, Fat = 5% fat in *longissimus* muscle.

[c]Expressed as a percentage of slaughter weight.

[d]Expressed as a percentage of cold carcass weight.

TABLE 6. CHEMICAL ANALYSIS OF SOFT TISSUE FROM 9-10-11 RIB CUT OF ANIMALS BORN IN 1971 ADJUSTED FOR DIFFERENCES IN AGE AND DAYS ON FEED

Item	Dam breed	H.H. A.A.	A.H. H.A.	J.H. J.A.	SD.H. SD.A.	L.H. L.A.	C.H. C.A.	S.H. S.A.	SD[b]
		Breed groups[a]							
No. of animals	H	27	37	23	18	26	27	26	
	A	26	31	22	17	27	19	27	
Moisture, %	H	43.9	40.7	42.4	43.1	46.8	48.9	45.9	
	A	40.1	40.3	41.8	40.9	47.2	45.7	45.3	
	Avg	42.0	40.5	42.1	42.0	47.0	47.3	45.6	2.9
Chemical fat, %	H	43.1	47.3	44.9	43.6	39.4	36.5	40.1	
	A	48.0	47.8	45.9	46.9	39.5	40.2	41.3	
	Avg	45.6	47.6	45.4	45.2	39.5	38.4	40.7	3.5
Protein, %	H	11.9	11.0	11.7	12.3	12.8	13.6	13.0	
	A	10.9	10.9	11.3	11.2	12.3	13.1	12.4	
	Avg	11.4	11.0	11.5	11.8	12.5	13.3	12.7	1.4
SE coefficient[b] X 100	H	30.6	26.2	33.0	37.7	38.1	30.2	31.2	
	A	30.7	27.9	35.0	37.0	34.0	40.0	30.1	
	Avg	25.7	23.1	26.3	26.7	29.8	31.5	26.2	

[a]H = Hereford, A = Angus, J = Jersey, SD = South Devon, L = Limousin, C = Charolais, S = Simmental. Breed of sire is given first and breed of dam is given second.

[b]Standard error of a least squares mean can be determined by multiplying the SE coefficient X standard deviation of a trait, e.g., SE of moisture for H.H. = .306 X 2.9 = .89.

straightbred Herefords and Simmental-Hereford crosses and lightest in Jersey-Angus crosses. Hide weights of breed groups with Hereford dams were significantly heavier than breed groups with Angus dams.

Carcass Weight, Dressed Yield and Cooler Shrinkage. Hot carcass weights (table 2) indicate large differences in average growth rates of breed groups. Charolais sired steers were significantly heavier and Jersey sired steers significantly lighter than any other sire breed groups. Average carcass weights of South Devon- and Limousin-sired steers did not differ significantly but all other pairwise comparisons differed by more than twice the standard error of their differences. Carcass weights adjusted to 5% *longissimus* fat (table 4) were similar for Charolais, Simmental, and Limousin and much heavier than other breed groups. Angus steers or steers with Angus dams reached 5% fat in the *longissimus* muscle when 12 to 14 kg lighter than Hereford steers or steers with Hereford dams.

Dressing percentage (table 5) did not differ significantly among sire breed groups even though hide weight, fatness and muscling conformation differed significantly. Limousin-sired steers had the highest and Jersey-sired steers the lowest dressing percentage yet the opposite was true for amount of fat in their carcasses.

Cold carcass weight was twice the sum of retail product, fat trim and bone of the right side. The difference between cold and hot carcass weight is a measure of cooler shrinkage which includes losses in moisture as well as cutting losses. Differences among breed groups were not significant and averaged 3.2%.

Bone. Bone in this study included bone, major tendons and excised ligaments. The fraction of total bone left in the short loin and the partially boneless rib was .157 in an evaluation by H. B. Hedrick, University of Missouri (*personal communication*), of 49 Hereford steers. If the fraction in these data is similar, total bone can be approximated by dividing bone values in the tables by .843.

Simmental crosses and Charolais crosses had significantly more bone than other breed groups. However, differences in percentage of bone (table 5) were small on a weight constant basis and even smaller when compared at equal fat in the *longissimus* muscle.

Retail Product and Roasts. All differences among sire breed group means for retail product compared at a constant age (table 2) were statistically significant. Compared at equal carcass weights (table 3), the average of straightbred Hereford and Angus did not differ significantly from their reciprocal crosses. Also, Charolais and Limousin sired groups did not differ significantly at equal carcass weights. All other comparisons exceeded twice the standard error of their difference. Charolais and Limousin crosses had the highest amount of retail product and roasts and Jersey crosses had the lowest. When least squares means were adjusted to 5% fat in the *longissimus* muscle (table 4), Charolais, Limousin, and Simmental crosses had similar carcass weights and amount of retail product. Percentages of retail product for those three breed groups (table 5) were higher than Hereford-Angus, Jersey, or South Devon crosses.

Differences among breed groups at equal carcass weights were significant for percentage of roasts (table 5) with the differences due primarily to variation in carcass fatness rather than roasts *vs* lean trim. Roast meat, as a fraction of retail product, was essentially the same for all sire breed groups.

Muscle to bone ratio was suggested as a measure of muscling differences by Berg and Butterfield (1966, 1968). No directly comparable measure is available in these data, but retail product and bone provide a similar measure. Breed group means for weight of retail product (tables 2 and 3) were highly correlated with bone, r = .9 and .8, respectively. However, correlations of mean weight of retail product with the ratio of retail product to bone (tables 2 and 3) were low, r = .3 and .1, respectively. When breed group means were adjusted by the subclass regression on days fed to the same average weight of retail product (193 kg) the corresponding weight of bone for breed crosses was: Hereford-Angus, 34.4; Limousin, 34.8; South Devon, 35.5; Jersey, 36.3; Charolais, 36.7; and Simmental, 37.7 kilograms. Thus, ratio of retail product to bone does not correspond closely with growth rate of retail product (table 2) or with relative proportion of retail product (table 3). Differences in intramuscular fat may have influenced the muscle to bone ratio as reported by Johnson and Pryor (1974).

Fat Trim, Kidney and Pelvic Fat, and Fat Thickness. Fat trim in these data includes kidney knob and pelvic fat. Since variation in percentage of bone was relatively small, differences in percentage of fat trim essentially mirror differences in retail product. Charolais, Simmental and Limousin crosses had the lowest percentage of fat trim while Jersey crosses had the highest percentage.

Kidney and pelvic fat was significantly higher in Jersey crosses than all other breed groups (table 3). Johnson *et al.* (1972) reported that weight of fat in the various depots (subcutaneous, intermuscular, intramuscular, kidney and channel fat) increases linearly with total dissected fat. Therefore, breed groups means were adjusted by the subclass regressions on days fed to the same average total fat trim (54.4 kg). Breed cross means for kidney and pelvic fat at 54.4 kg total fat trim were: Hereford-Angus, 8.7; South Devon, 11.6; Simmental, 12.6; Limousin and Charolais, both 12.9; and Jersey, 14.1 kilograms.

Fat thickness was closely related to amount of fat trim among the 14 breed group means adjusted to an equal carcass weight (table 3). The regression of fat trim on fat thickness was 3.2 kg per millimeter and the correlation was .9 among breed group means. Among animals within breed groups the regression was 1 kg per millimeter and the correlation .6.

Charolais, Simmental and Limousin crosses had less fat at the 12th rib than other breed groups when measured on an age or weight constant basis. Breed cross means for fat thickness when all were adjusted to the same total fat trim (54.4 kg), were: Jersey, South Devon and Simmental, each 1.1; Charolais, 1.2; Limousin, 1.3; and Hereford-Angus, 1.4 centimeters.

Longissimus Muscle Fat and Area. Jersey cross carcasses had significantly more *longissimus* fat than other sire breed groups. At equal age and days fed or at equal carcass weight Limousin, Charolais and Simmental crosses had significantly lower *longissimus* fat percentages than other sire breed groups. However, *longissimus* fat of breed cross means when adjusted by subclass regression on days fed to equal total fat trim (54.4 kg) were Jersey, 6.0%; Charolais, 5.5%; Simmental, and Hereford-Angus, each 5.2%; South Devon, 5.1% and Limousin, 4.7%.

Comparisons of breed group means for *longissimus* area are appropriately made at common carcass weights (table 3). Breed groups with larger *longissimus* areas had higher percentages of retail product. Regression of breed group means for retail product on area was 2 kg per cm^2, and the correlation was .93. Limousin cross carcasses had the largest area, exceeding Charolais crosses even though retail product was similar for the two breed groups. Difference in area when mass is similar is likely due to length of muscle (Butterfield, 1963). Jersey crosses had the smallest *longissimus* muscle areas.

Yield Grade. Yield grade was calculated from the U.S.D.A. (1965) formula. Breed group means (table 3) for retail product and yield grade were closely related: The regression was −17.9 kg per yield grade. Limousin, Charolis and Simmental crosses had significantly lower average yield grades than other sire breeds.

Relative ranks of breeds or crosses observed for yield of edible portion and fat trim generally agree with results from other studies on Hereford, Angus and Jersey carcasses by Cole *et al.* (1964); on Hereford, Angus and Charolais crosses by Hedrick *et al.* (1970) and Fredeen *et al.* (1972); on Hereford, Angus, Charolais, Limousin and Simmental crosses by Adams *et al.* (1973); and South Devon, and Simmental crosses by Newman *et al.* (1974).

Chemical Analysis of 9-10-11th Rib Cut. Results of chemical analyses of the 9-10-11th rib cut from steers born in 1971 are shown in table 6. The results tend to agree with other measures of fatness: Charolais, Limousin and Simmental crosses had significantly less fat than other breed groups. Jersey crosses had lower fat percentages than expected with their high *longissimus* and total fat trim values. Relatively low subcutaneous fat of Jersey crosses coupled with kidney and pelvic fat differences that are not reflected in the 9-10-11th rib cut may be the explanation.

Quality Measures and Taste Panel Evaluation

Analysis of Variance. Table 7 summarizes analyses of variance for carcass quality traits and for taste panel evaluation. Breed of sire was a significant source of variation for quality grade and for each of its components. Warner-Bratzler shear and taste panel tenderness and acceptability also differed significantly for sire breeds but neither taste panel juiciness nor flavor differed significantly among sire breeds. Breed of dam was a significant source of variation for most traits, but breed of sire by breed of dam interactions were not significant. Regression on days fed was significant for quality grade, marbling and maturity but not for conformation, Warner-Bratzler shear or taste panel evaluation. Least squares means

TABLE 7. ANALYSIS OF VARIANCE OF QUALITY MEASURES AND TASTE PANEL EVALUATION

		Mean squares													
Source	df	Quality grade	Confor-mation	Marbling	Skeletal maturity	Lean maturity	Final maturity	Color	Texture	Firmness	W-B shear	Tender-ness	Flavor	Juici-ness	Accept-ability
Breed of sire (BS)	6	32.0**	107.1**	260**	.75**	3.54**	.96**	9.47**	2.51**	6.68**	4.16**	3.36**	.22	.63	1.17**
Breed of dam (BD)	1	74.3**	52.6**	400**	.10	1.77**	.06	12.98**	9.01**	11.24**	.11	3.21*	.13	.46	1.14
Year (Y)	2	170.1**	4.9**	1033**	32.93**	47.22**	36.06**	14.98**	53.19**	14.01**	6.91**	.59	.29	3.27	.10
Age of dam	3	1.0	3.8**	3	.51*	1.11**	.39	1.60*	.36	.69	.32	.80	.31	.21	.31
BS X BD	6	1.0	.7	3	.12	.36	.17	.65	1.15*	.30	.87	1.38	.15	.48	.44
BS X Y	12	3.2**	3.7**	16*	.14	.49	.14	.93	.61	.46	.66	.94	.13	.62	.40
BD X Y	2	.7	1.8	2	.07	.41	.11	.99	.41	.31	.88	1.06	.13	1.11	.33
b_1 (starting age)	1	11.5**	2.1	74**	.23	.04	.12	.03	.37	.25	.12	.22	.02	.89	.01
b_1 X BS	6	3.5*	.6	21*	.28	.26	.26	.37	.67	.79	.24	.23	.14	.13	.06
b_1 X BD	1	.4	.9	11	.11	.25	.24	.31	.08	.03	.25	.55	.11	.32	.17
b_2 (days fed)	1	61.8**	.2	617**	44.58**	30.02**	44.35**	6.60**	.24	.00	.14	.87	.00	.00	.01
b_2 X BS	6	2.0	.4	17	.05	.15	.05	.20	.44	1.13*	.29	.31	.12	.14	.19
b_2 X BD	1	3.8	.1	13	1.02*	.03	.93**	.00	.49	1.08*	.04	.82	.01	.00	.01
b_2 X BS X BD	6	.7	.8	7	.18	.49	.30	.66	.37	.29	.18	.34	.26	.33	.09
Residual	1066 (441)[a]	1.4	1.0	9	.16	.26	.17	.58	.44	.40	.45	.69	.18	.38	.36

*P<.05.

**P<.01.

[a]Degrees of freedom for taste panel traits.

adjusted by subclass regressions to a starting age of 240 days and 217 days fed are shown in tables 8 and 9. Adjustment of means to a common carcass weight by subclass regressions on days fed, as outlined earlier for composition traits, was not done because the only traits affected were slight changes in maturity, marbling and quality grade. Changes in marbling and quality grade from an age constant to a weight constant basis follow the pattern for *longissimus* fat percentage given in tables 2 and 3.

Heterosis was not significant for any factors comprising quality grade or for taste panel evaluation.

Quality Grade. Quality grade was based on separate evaluation of conformation and on characteristics that indicate palatability although recently proposed changes in the grading standards removes conformation from consideration in grades. Palatability indicators included marbling, skeletal maturity, lean maturity, color, texture and firmness of lean.

Angus had higher average quality grade than Herefords. Among crossbred types Hereford-Angus, Jersey and South Devon crosses graded significantly higher than Limousin, Charolais or Simmental crosses.

Conformation. Conformation was based on thickness of muscling and overall thickness and fullness of the carcass in relation to length.

Limousin and Charolais crosses were significantly higher and Jersey crosses lower in average conformation than other breed crosses. Variation in conformation was similar within all breed groups.

Marbling. Breed group means for marbling were closely correlated (r = .96) with means for fat percentage in the *longissimus* muscle (tables 2 and 8). Marbling scores were significantly higher for Angus than for Herefords, and higher for Jersey and lower for Limousin crosses than for other breed crosses. Lower quality grade relative to average marbling for breed group means (table 8) was due partially to adjustment for differences in conformation and measures of maturity, but also to a difference in scaling of marbling and quality grade. Each grade and each degree of marbling was subdivided into three units (–, o, +). Prime and Choice grades each include three degrees of marbling (9 units), while Good and Standard each include only one and one-half degrees of marbling (4.5 units). Within breed groups, marbling increased an average of .028 ± .003 unit per day during the last 60 days on feed.

Maturity, Color, Texture and Firmness. All animals in this study were less than 18 months of age when slaughtered, and breed groups were within a few days of having the same average chronological age (457 days). All carcasses were classified A– or A maturity. Jersey crosses averaged significantly higher in maturity measures than the other crosses. Maturity rank of breed crosses, based on average final maturity score was (1) Jersey, (2) Simmental, (3) Hereford-Angus and South Devon (equal), (4) Limousin and (5) Charolais. This ranking agrees with the maturity ranking based on average age at puberty of heifer mates of the steers evaluated here (Laster *et al.*, 1976).

Color and texture of lean change with maturity. Deviations in color or texture from expectation for a given degree of maturity contributed to differences in evaluation of lean quality. Differences in breed group means for lean maturity were primarily related to differences in color of lean. Hereford carcasses were slightly darker with less fine texture than Angus carcasses. Among crossbred groups Simmental and Jersey crosses averaged slightly darker and less fine texture than other groups but these differences were not of practical importance.

Firmness as a measure of lean quality is considered in relation to marbling and maturity. Differences between breed group means for firmness were closely correlated with differences in marbling (r = .97).

Warner-Bratzler Shear. Warner-Bratzler (W-B) shear force, as kilograms per 12.7 mm core, provides a measure of tenderness. Means for Jersey and South Devon crosses were significantly lower while Limousin and Simmental crosses were significantly higher than other breed groups. Ramsey *et al.* (1963) reported Jersey carcasses had the lowest shear values of breeds they studied. Though differences in this study are statistically significant the difference between the highest and lowest mean was only .47 kg and all are in the acceptable range of tenderness. The correlation between W-B shear and marbling was low (r = –.10) among individual animals within a breed group but high (r = –.70) between breed group means. The regression of means for W-B shear on marbling was –.09 kg per unit of marbling, thus, a change of 11 units of marbling was associated with a change of 1 kg in W-B shear. The regression of W-B shear on starting age was .8 g/day while the regression on days fed was

TABLE 8. LEAST SQUARES MEANS FOR CARCASS QUALITY TRAITS ADJUSTED TO A STARTING AGE OF 240 DAYS AND 217 DAYS ON FEED

		Breed group[a]								
Trait	Dam breed	H.H. A.A.	A.H. H.A.	J.H. J.A.	SD.H. SD.A.	L.H. L.A.	C.H. C.A.	S.H. S.A.	Avg	SD[b]
No. of animals	H	69	97	53	44	87	78	82	510	
	A	85	113	81	50	88	99	95	611	
Quality grade[c]	H	9.23	10.04	9.56	9.57	8.64	9.03	8.95	9.29	
	A	10.43	9.73	10.26	10.16	9.00	9.84	9.45	9.84	
	Avg	9.83	9.88	9.91	9.87	8.82	9.44	9.20	9.56	1.20
Conformation[c]	H	11.14	11.67	9.05	10.97	11.92	11.94	11.40	11.16	
	A	11.97	11.77	9.50	11.40	12.43	12.55	11.70	11.62	
	Avg	11.56	11.72	9.27	11.19	12.18	12.25	11.55	11.39	.97
Marbling[d]	H	10.11	12.24	13.05	11.19	8.94	10.04	9.79	10.76	
	A	13.07	11.48	14.58	12.47	9.98	11.60	11.09	12.04	
	Avg	11.59	11.86	13.81	11.83	9.46	10.83	10.44	11.40	2.99
Skeletal maturity[e]	H	1.38	1.41	1.59	1.45	1.35	1.35	1.40	1.42	
	A	1.37	1.37	1.60	1.29	1.33	1.39	1.44	1.40	
	Avg	1.38	1.39	1.60	1.37	1.34	1.37	1.42	1.41	.40
Lean maturity[e]	H	1.60	1.49	1.92	1.74	1.60	1.52	1.84	1.68	
	A	1.44	1.63	1.83	1.50	1.65	1.34	1.75	1.59	
	Avg	1.52	1.56	1.88	1.62	1.63	1.43	1.80	1.63	.51
Final maturity[e]	H	1.36	1.42	1.64	1.49	1.36	1.34	1.42	1.43	
	A	1.39	1.38	1.62	1.31	1.41	1.35	1.46	1.42	
	Avg	1.37	1.40	1.63	1.40	1.38	1.34	1.44	1.43	.41
Color of lean[f]	H	2.16	1.95	2.46	2.36	2.22	2.07	2.66	2.27	
	A	1.82	2.07	2.24	1.86	2.06	1.71	2.50	2.04	
	Avg	1.99	2.01	2.35	2.11	2.14	1.89	2.58	2.15	.76
Texture of lean[g]	H	2.08	1.96	2.28	2.37	2.20	2.09	2.47	2.21	
	A	1.97	2.00	2.13	1.73	2.05	2.00	2.22	2.01	
	Avg	2.02	1.98	2.20	2.05	2.13	2.04	2.34	2.11	.66
Firmness of lean[h]	H	2.05	1.78	1.73	1.84	2.33	2.19	2.23	2.02	
	A	1.62	1.94	1.41	1.72	2.07	1.99	1.89	1.80	
	Avg	1.84	1.86	1.57	1.78	2.20	2.09	2.06	1.91	.63
Warner-Bratzler shear, kg	H	3.14	3.10	3.04	3.07	3.41	3.26	3.51	3.22	
	A	3.21	3.36	2.99	2.90	3.45	3.07	3.41	3.20	
	Avg	3.18	3.23	3.02	2.99	3.43	3.17	3.46	3.21	.67
SE coefficient × 100[b]	H	12.2	10.4	14.9	15.4	12.1	11.6	11.4	4.8	
	A	11.4	9.8	12.7	14.6	11.4	10.6	10.5	4.4	
	Avg	8.4	7.2	10.3	10.5	8.8	7.9	7.9	3.3	

[a]H = Hereford, A = Angus, J = Jersey, SD = South Devon, L = Limousin, C = Charolais, S = Simmental. Breed of sire is given first and breed of dam is given second.

[b]Standard error of a least squares mean can be determined by multiplying the SE coefficient × standard deviation of a trait, e.g., SE of quality grade for H.H. = .122 × 1.20 = .146.

[c]Quality grade and conformation: 15, 14, 13 = Prime; 12, 11, 10 = Choice; 9, 8, 7 = Good; 6, 5, 4 = Standard.

[d]Marbling: 24, 23, 22 = moderately abundant; 21, 20, 19 = slightly abundant; 18, 17, 16 = moderate; 15, 14, 13 = modest; 12, 11, 10 = small; 9, 8, 7 = slight; 6, 5, 4 = traces; 3, 2, 1 = practically devoid.

[e]Maturity: 1 = A^-; 2 = A; 3 = A^+.

[f]Color: 1 = very light cherry red; 2 = cherry red; 3 = slightly dark red; 4 = moderately dark red; 5 = dark red; 6 = very dark red; 7 = black.

[g]Texture: 1 = very fine; 2 = fine; 3 = moderately fine; 4 = slightly fine; 5 = slightly coarse; 6 = coarse, 7 = very coarse.

[h]Firmness: 1 = very firm; 2 = firm; 3 = moderately firm; 4 = slightly soft; 5 = soft; 6 = very soft; 7 = extremely soft.

TABLE 9. LEAST SQUARES MEANS OF TASTE PANEL EVALUATION ADJUSTED TO A STARTING AGE OF 240 DAYS AND 217 DAYS ON FEED

		Breed groups[a]								
Trait	Dam breed	H.H. A.A.	A.H. H.A.	J.H. J.A.	SD.H. SD.A.	L.H. L.A.	C.H. C.A.	S.H. S.A.	Avg	SD[b]
No. of	H	36	36	31	34	36	36	35	244	
animals	A	37	36	36	36	35	35	37	252	
Tenderness[c]	H	7.32	7.47	7.57	7.34	6.85	7.18	6.62	7.19	
	A	7.28	7.30	7.44	7.60	7.15	7.53	7.20	7.36	
	Avg	7.30	7.38	7.51	7.47	7.00	7.36	6.91	7.28	.83
Flavor[c]	H	7.45	7.50	7.65	7.45	7.55	7.52	7.38	7.50	
	A	7.53	7.44	7.60	7.52	7.48	7.59	7.59	7.53	
	Avg	7.49	7.47	7.63	7.48	7.52	7.56	7.48	7.52	.43
Juiciness[c]	H	7.00	7.13	7.32	7.13	7.12	7.11	6.92	7.11	
	A	7.09	7.07	7.35	7.28	7.02	7.07	7.30	7.17	
	Avg	7.04	7.10	7.34	7.21	7.07	7.09	7.11	7.14	.62
Accept-	H	7.26	7.34	7.51	7.29	7.02	7.27	6.89	7.22	
ability[c]	A	7.26	7.27	7.42	7.42	7.21	7.41	7.26	7.32	
	Avg	7.26	7.30	7.47	7.36	7.12	7.34	7.07	7.27	.60
SE coeffi-	H	16.8	17.0	18.8	17.3	18.0	17.4	17.2	6.6	
cients X 100[b]	A	16.9	16.9	18.0	17.0	17.5	17.1	17.0	6.5	
	Avg	11.9	12.1	13.3	12.3	12.9	12.2	12.3	4.7	

[a]H = Hereford, A = Angus, J = Jersey, SD = South Devon, L = Limousin, C = Charolais, S = Simmental. Breed of sire is given first and breed of dam is given second.

[b]Standard error of a least squares mean can be determined by multiplying the SE coefficient X standard deviation of a trait, e.g., SE of tenderness of H.H. = .168 X .83 = .139.

[c]1 = extremely undesirable, 2 = undesirable, 3 = moderately undesirable, 4 = slightly undesirable, 5 = acceptable, 6 = slightly desirable, 7 = moderately desirable, 8 = desirable, 9 = extremely desirable.

−.4 g/day. These regressions, though not statistically significant, do suggest that as animals grow older, force required to shear samples increases, but longer feeding compensates for increased age such that no change, or possibly a slight negative regression on days fed, may be observed.

Taste Panel Evaluation. Taste panel evaluation (table 9) was based on a nine-point hedonic scale, 1 = extremely undesirable, ... 5 = acceptable, ... 9 = extremely desirable. All breed group means were significantly above the minimum level for acceptance. Differences among sire breed group means for tenderness, though small, were statistically significant. Jersey and South Devon crosses were more tender while Limousin and Simmental crosses were less tender, in agreement with Warner-Bratzler shear determinations. Within breed groups, the average regressions of taste panel tenderness and acceptability on days fed were slightly, but not significantly, negative. The desirable influence of marbling was essentially counteracted by the undesirable influence of increased age at the states of maturity represented in this study. Flavor and juiciness breed group means did not differ significantly. It is somewhat surprising that differences among breed groups for marbling were not reflected in significant differences in juiciness. Breed group means for acceptability differed significantly and were closely correlated with means for tenderness (r = .97).

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