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CARCASS AND MEAT STUDIES

A Literature Review

By

C. B. ROUBICEK, R. T. CLARK and O. F. PAHNISH

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RANGE CATTLE PRODUCTION

A Literature Review

Section V

CARCASS AND MEAT STUDIES

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RANGE CATTLE PRODUCTION

CARCASS AND MEAT STUDIES

Carcass Yield

It has been pointed out that in general it is the vital organs used for maintenance of life which develop first, while the parts which are used for production--fat, muscle, udder, etc.,--develop later. The "offal" parts of the body, such as the alimentary canal, head, and legs, develop early in life, while the valuable parts,such as the loin, develop late (62). The development of the different joints of the body region exhibits a marked gradient of increasing growth rate from the head and feet to the loin region, the feet and head growing least and the loin most in postnatal life (137). It has been concluded that breed improvement for beef consists in rearing animals on a high plane of nutrition and selecting for breeding purposes those which go through the age change in proportions quickest and to the fullest extent (62)(63). For the full expression of these developmental characters a high plane of nutrition is necessary, for if it is not available the later maturing and more valuable parts are not developed (60).

It has been found that calves receiving a supplement after weaning so that they gained about one pound daily showed an advantage in the proportions of desirable wholesale cuts. Although there was no difference in the final condition of the animals, those receiving supplement yielded relatively more hindquarter (56).

Steers on maintenance and submaintenance rations lost weight from the hindquarters more rapidly than from the forequarters. The supermaintenance animals gained more in hindquarters than in forequarters (167).

Actual cut-out values indicate that the age of animals (calves, yearlings, two-year-olds) has little influence on the percentages of the various cuts of beef (45)(52)(76)(83).

TABLE I

Summary of Carcass Cut-out (45)

Item	Immature* Steer	Mature* Steer
Slaughter weight	852	1590
Chilled carcass weight	476.5	947.9
Percentage forequarter	51.83	52.43
Percentage hindquarter	48.05	47.68
Percentage wholesale cuts:		
Round	23.94	21.72
Loin	16.95	16.01
Rib	9.11	9.86
Flank	6.28	5.79
Plate	11.34	11.41
Chuck	24.58	26.53
Fore shank	4.56	3.53
Neck	1.72	1.65
Kidney fat	1.21	3.50

* The immature steer was a 12-month-old Shorthorn weighing 852 lbs. The mature steer was a 9-year-old Hereford weighing 1,590 lbs.

TABLE II

Summary of Age Trials, 175-Day Feeding Period (52)

	Two-year-old Steers	Yearling Steers	Steer Calves
Carcass weight	696	588	412
Dressing percentage	59.85	58.72	55.25
Percentage of:			
Fore	51.63	51.66	50.39
Hind	48.37	48.34	49.61
Chuck	27.27	27.57	26.94
Rib	10.11	10.05	9.70
Plate	11.88	11.74	11.04
Shank	2.71	2.75	3.03
Loin	18.17	18.25	18.79
Round	22.74	22.45	24.14
Flank	4.37	4.45	4.29
Kidney	2.44	2.61	2.09

TABLE III

Summary of Age Trials, 175-Day Feeding Period (52)

	Two-year-old Spayed Heifers	Yearling Open Heifers	Open Heifer Calves
Carcass weight	639	562	428
Dressing percentage	59.77	59.39	58.91
Percentage of:			
Fore	49.69	49.22	49.53
Hind	50.31	51.28	50.47
Chuck	25.61	25.40	26.18
Rib	9.78	9.89	10.06
Plate	12.13	11.53	10.67
Shank	2.90	2.47	2.90
Loin	19.35	19.29	18.86
Round	21.57	22.61	23.56
Flank	5.50	5.62	5.22
Kidney	3.31	3.03	2.37

In comparing the carcass cut-out of steers and heifers, the results generally indicate that heifers have a somewhat greater proportion of hindquarter than do steers (21)(46)(52). Heifers, both open and spayed, fatten faster than steers (22)(46)(52)(83). Bred heifers fatten faster than open heifers, but the loin ends of open heifers are 7 percent heavier and rounds 11 percent heavier than of bred heifers (159). Exercise does not affect the cutting percentages (23). Compress and conventional type Herefords did not differ significantly in the percentage of wholesale cuts when they were carried to a similar slaughter grade (152)(161)(162)(165)(181).

Twenty different measurements taken on the live animal were correlated with two different sets of wholesale cuts: (a) round, loin, and rib; (b) round, loin, rib, and square cut (53)(54)(176). Depth, length, and circumference measurements were taken at various points on the body.

After the effects of differences in body weights had been removed, it was found that these measurements had little if any use for predicting the weights of cuts.

The weights of 17 wholesale cuts were correlated with each other as well as with live weight and slaughter grade. In general, meaty cuts were highly correlated with other meaty cuts, indicating that careful selection for muscling in one part would help in selection for another desirable but less visible part.

It was indicated that thickness of body wall in the flank region may be an important indicator of the deposition of fat and might be useful as an earlier indicator of fattening than the laying down of fat along the lower border of the flank.

There are apparent differences in carcass proportions between beef and dairy breeds (83). The cut-out values of 1,100-pound Holstein steers were as follows (129):

TABLE IV

Summary of Carcass Data--Steers and Heifers (22)

	Steers				Heifers		
	Days on Feed						
	0	140	200	266	0	140	200
No. of animals	2	3	4	3	2	5	5
Average slaughter weight	382	688	864	850	370	712	822
Average daily gain	0	2.52	2.35	2.06	0	2.56	2.36
Dressing percentage	50.7	58.5	60.2	62.1	50.3	58.2	61.5
Percentage cold carcass weight:							
Round	23.3	19.4	17.2	16.7	22.0	18.1	16.5
Rump	5.7	5.1	4.9	5.6	5.4	5.4	5.0
Loin	15.4	15.6	15.4	14.7	15.3	16.9	15.8
Loin end	9.1	8.6	8.7	8.0	9.0	9.2	8.8
Short loin	6.2	7.0	6.8	6.7	6.2	7.6	7.1
Kidney knob	1.4	3.4	3.6	4.5	2.2	3.8	4.0
Flank	3.0	5.3	5.9	6.7	4.2	5.8	7.8
Ribs	8.7	9.7	9.9	10.4	9.3	9.8	9.9
Navel	5.4	6.6	7.0	6.8	5.9	6.7	6.9
Brisket	3.7	4.5	4.6	4.2	3.7	4.5	4.6
Chuck	27.0	25.2	27.2	26.3	25.8	24.6	25.3
Shank	5.4	3.6	3.4	3.3	4.7	3.2	3.0
Lean	64.5	57.0	54.8	54.1	58.7	55.9	51.0
Fat	10.7	29.5	31.5	32.6	17.5	30.6	27.0
Bone	20.8	13.1	13.5	12.9	20.8	12.5	10.9
Tendon	2.0	.7	.6	.5	1.8	.6	.7

TABLE V

Summary of Age and Sex Trials, 175-Day Feeding Period (52)

	Lot Number							
	1	2	3	4	5	6	7	8
Carcass weight	696	639	588	527	562	412	387	428
Dressing percentage	59.85	59.77	58.72	57.33	59.39	55.25	57.20	58.91
Cutting yields, percentage of carcass weight:								
Fore	51.63	49.69	51.66	49.95	49.22	50.39	48.77	49.53
Hind	48.37	50.31	48.34	50.05	51.28	49.61	51.23	50.47
Chuck	27.27	25.61	27.57	25.90	25.40	26.94	26.93	26.18
Rib	10.11	9.78	10.05	10.15	9.89	9.70	9.37	10.06
Plate	11.88	12.13	11.74	11.93	11.53	11.04	10.31	10.67
Shank	2.71	2.90	2.75	2.78	2.47	3.03	2.87	2.90
Loin	18.17	19.35	18.25	18.72	19.20	18.79	19.15	18.82
Round	22.74	21.57	22.45	22.31	22.61	24.14	23.67	23.56
Flank	4.37	5.50	4.45	5.52	5.62	4.29	5.45	5.22
Kidney	2.44	3.31	2.61	2.93	3.03	2.09	2.46	2.37

Lot 1 = two-year-old steers
Lot 2 = two-year-old spayed heifers
Lot 3 = yearling steers
Lot 4 = yearling spayed heifers
Lot 5 = yearling open heifers
Lot 6 = steer calves
Lot 7 = spayed heifer calves
Lot 8 = open heifer calves

TABLE VI

Carcass Data from Steers and Heifers (46)

	Steers Lot					Heifers Lot		
	1	2	3	4	5	1	2	4
No. of animals	16	16	16	16	16	8	8	8
No. slaughtered	2	2	2	2	2	1	1	1
Initial weight	347	352	317	366	371	350	383	362
Final weight	772	570	469	978	843	733	675	942
Ave. daily gain	2.16	1.11	.77	1.82	1.41	1.95	1.49	1.72
Slaughter weight	750	568	440	941	846	725	630	920
Cold carcass wt.	436	314	227	561	466	420	345	558
Dressing percent	58.10	55.32	51.47	59.62	55.02	57.93	54.76	60.65
Percent forequarter	50.6	51.0	51.3	51.5	51.8	48.3	49.1	49.1
Percent hindquarter	49.4	49.0	48.7	48.5	48.2	51.7	50.9	50.9
Percentage wholesale cuts:								
Round	23.7	27.8	28.5	23.6	24.4	23.1	25.7	23.4
Loin	18.4	16.6	17.0	17.0	16.3	17.8	17.5	16.8
Flank	4.4	2.7	2.3	4.7	4.3	5.7	5.0	7.1
Rib	9.1	8.6	9.1	9.9	9.5	9.2	8.3	12.0
Chuck	21.8	23.2	21.5	21.3	22.5	20.0	20.8	17.3
Plate	13.1	11.0	9.6	12.9	12.1	13.0	12.5	11.0
Kidney knob	2.9	4.1	1.4	2.4	1.3	3.0	3.7	3.0
Percentage lean:								
Round	62.5	69.3	68.7	63.8	66.3	74.2	66.5	63.6
Loin	55.6	68.9	67.9	56.8	61.6	54.8	63.2	57.2
Rib	48.0	62.9	61.8	55.1	57.5	49.5	57.3	55.8
Chuck	61.1	70.2	68.8	62.9	68.1	60.4	65.8	60.0
Plate	45.8	61.5	58.9	47.1	55.0	45.6	52.4	48.8
Total side	54.0	65.8	63.9	55.4	60.4	52.7	60.0	54.2
Percentage fat:								
Round	20.0	9.6	8.5	19.4	14.5	18.2	14.7	21.6
Loin	32.5	17.3	14.7	30.2	25.9	32.8	22.5	31.8
Rib	35.4	13.6	10.8	28.3	21.7	34.3	22.4	32.0
Chuck	22.8	9.3	10.8	21.3	15.0	24.0	17.8	25.3
Plate	41.3	18.3	17.8	40.1	28.6	41.9	23.2	39.5
Total side	30.3	14.2	12.9	29.3	23.0	32.8	23.3	32.7
Percentage bone:								
Round	17.5	21.1	22.9	16.8	19.3	17.6	18.8	14.7
Loin	11.8	13.8	17.5	13.0	12.4	12.3	14.2	10.9
Rib	16.6	23.5	27.4	16.7	20.8	16.1	20.3	12.2
Chuck	16.1	20.5	20.4	15.8	16.9	15.6	17.4	14.7
Plate	12.9	20.1	23.4	12.9	16.4	12.5	16.3	11.6
Total side	15.0	20.0	22.9	15.0	16.4	14.4	17.0	13.1

Lot 1 = Full fed grain and roughage 196 days.
Lot 2 = Fed half grain ration and roughage 196 days.
Lot 3 = Roughage only 196 days.
Lot 4 = Half grain ration and roughage 168 days, then full fed grain on pasture 168 days.
Lot 5 = Roughage only 168 days, grazed 56 days, then full fed 112 days.

TABLE VII

"Cut-out" Values of Holstein Steers (129)

Grade	Round	Loin	Rib	Chuck	Plate
	Average Percent in Each Wholesale Cut				
Good	24.97	24.61	9.27	33.59	7.55
Commercial	25.52	22.33	9.03	36.29	6.83
Utility	26.24	21.47	9.11	37.12	6.07
Cutter	28.94	19.22	8.74	37.14	5.93

A summary of comparative carcass characteristics of British and Brahman cattle has been made (171).

TABLE VIII

Comparative Carcass Characteristics of British and Brahman x British Cattle when Slaughtered as Weanling Calves

	Brahman x British		British x British		Differences
	No.	Ave.	No.	Ave.	Brahman-British
Dressing percent	106	57.8	165	56.8	1.0
Percent preferred cuts	4	50.1	4	49.2	.9
Percent Hindquarter	4	48.6	4	49.5	-.9
Percent lean	4	72.4	4	69.8	2.6
Percent fat	4	3.7	4	4.2	-.5
Percent bone	4	24.0	4	26.0	-2.0
Area rib eye	20	7.2	20	6.9	.3

TABLE IX

Comparative Carcass Characteristics of British and Brahman x British Cattle when Slaughtered as Fed Steers

	Brahman x British		British x British		Differences
	No.	Ave.	No.	Ave.	Brahman-British
Dressing percent	363	60.3	317	57.6	2.7
Percent preferred cuts	69	45.6	41	45.2	.4
Percent hindquarter	94	49.2	88	48.9	.3
9-10-11 rib:					
Percent lean	88	54.1	59	54.2	-.1
Percent fat	88	27.5	59	25.9	1.6
Percent bone	88	18.9	59	19.9	-1.0
Area eye	33	10.0	33	9.1	.9
Fat in eye	14	3.7	14	4.7	-1.0

Other studies (94)(95)(98)(139) show very little difference in the average percent of wholesale cuts although there may be considerable variation in type and conformation.

TABLE X

Average Percent of Wholesale Cuts from Steer Carcasses (94)

Carcass	Round %	Loin %	Prime Rib %	Chuck %	Flank %	Brisket & Plate %	Hind Quarters %	Preferred Cuts %
Brahman	22.8	15.6	9.4	25.4	6.2	15.6	50.0	50.8
Braford	22.8	15.5	9.8	25.1	5.4	16.1	49.5	51.3
Hereford	23.4	15.5	10.0	24.6	5.7	16.2	49.3	51.9
Hereford x Shorthorn	22.8	15.4	9.7	25.5	5.6	16.1	49.0	50.7

The Canadian government conducted an experiment using bulls of British breeds on bison cows (117). The hybrids were rather light in their hindquarters and heavy in their forequarters.

Lean-Fat-Bone Ratio

The food for human consumption that is produced from the feed utilized in fattening cattle is greater than is indicated by the gain in live weight. During the fattening process, the percentage nutrient content of the whole carcass is materially increased. This fact is frequently overlooked when comparisons are made between the efficiency of feeding cattle for fattening and the efficiency of feeding other kinds of livestock (136).

TABLE XI

Comparison of Edible Product and Food Nutrients Produced per 1,000 Feed Units1/ by Fattened Cattle and Other Livestock (136)

Class of livestock and kind of product	Yield per 1,000 units of feed consumed: Edible	Calories	Fat	Protein
Fattened cattle	76	157	36	8
Dairy cows				
Whole milk	901	276	34	31
Butter	69	212	51	2
Hogs				
Pork and lard	135	349	80	13
Chickens				
Eggs	165	113	18	20
Meat	103	83	12	19

1/ "Feed unit" is 1 pound of corn or equivalent quantities of other feeds having the same feed value as corn.

TABLE XII

Estimated Feed Consumption, Slaughter, Grade, Dressing Yield and Body Composition at Specified Live-weight Intervals During the Fattening Period (136)

Item	Average Live-Weight per Head in Pounds							
	400	500	600	700	800	900	1,000	1,100
T.D.N. consumed	0	402	837	1,326	1,886	2,541	3,328	4,316
Physically separable:								
Lean	144	174	202	231	262	291	322	349
Fat	23	38	57	82	112	150	196	249
Bone	41	49	58	67	75	85	94	104
Edible portion of carcass:								
Weight	167	212	259	313	374	441	517	598
Physically separable fat	23	37	55	79	198	145	189	242

TABLE XIII

Estimated Dressing Yield and Body Composition at Specified Live-weight Intervals During the Fattening Period (136)

Item	Average Live-Weight per Head in Pounds							
	400	500	600	700	800	900	1,000	1,100
Carcass:	%	%	%	%	%	%	%	%
Dressing percent	52	52	53	54	56	59	61	64
Physically separable:								
Lean	69	67	64	61	58	55	53	50
Fat	11	15	18	22	25	29	32	36
Bone	29	19	18	18	17	16	15	15
Edible portion of carcass:								
Physically separable fat	14	18	21	25	29	33	37	40

In most instances the results of a study on growth or fattening cannot be regarded as complete unless they include information on the composition of the animal body, or at least of the dressed carcass (72). Measuring growth or fattening in terms of live weight or by the determination of such characteristics as height, width, length, and girth of the animal is at best an indirect method and furnishes only a rough approximation of the nutritive value of the meat animal. However, the analysis of the entire body or carcass chemically, or even physically, is time-consuming and expensive.

In an attempt to find an easier method of evaluating a carcass, the 9, 10, 11th rib cut was compared to the entire carcass. A correlation of +0.91 between fat (ether extract) content of the edible portion of the 9, 10, 11th rib cut and the same constituent of the edible portion of the dressed carcasses of steer cattle was reported (69).

Another study with 92 head of cattle reported the following (86):

1. The physical composition of the whole and edible portion of the wholesale and 9, 10, 11th rib cuts is highly correlated with the physical composition of the empty body, carcass, and edible portion of the carcass. This is especially true in the case of percentage of fat.

2. The chemical composition of the whole and edible portion of wholesale rib cut is highly correlated with the chemical composition of the empty body, carcass, and edible portion of the carcass.

3. The percentages of ether extract in the eye muscle, fat, and bone of the 9, 10, 11th rib are not considered satisfactory indices of fatness.

4. The dressing percentage is not a reliable indicator of fatness expressed either as fat or as ether extract.

5. The edible portion of the 9, 10, 11th rib cut was selected as an indicator of the physical composition of the edible portion of the carcass:

X = lean, wholesale rib Y = lean, empty body	$r = 0.841$ $b = Y = 0.40422\,X + 15.89934$
X = lean, 9, 11th rib Y = lean, empty body	$r = .715$ $b = Y = .30270\,X + 22.65161$
X = fat, 9, 11th rib Y = fat, empty body	$r = .985$ $b = Y = .68371\,X + 1.61401$
X = bone, 9, 11th rib Y = bone, empty body	$r = .947$ $b = Y = .51327\,X + 5.04322$
X = lean, 9, 11th rib Y = lean, carcass	$r = .940$ $b = Y = .8173\,X + 15.71220$
X = fat, 9, 11th rib Y = fat, carcass	$r = .984$ $b = Y = .81774\,X + 2.27664$
X = lean, 9, 11th rib Y = lean, edible carcass	$r = .940$ $b = Y = .80161\,X + 17.17102$
X = fat, 9, 11th rib Y = fat, edible carcass	$r = .983$ $b = Y = .92088\,X + 3.84738$
X = bone, 9, 11th rib Y = bone, carcass	$r = .941$ $b = Y = .70750\,X + 3.47863$

Procedures have been outlined for obtaining the 9, 10, 11th rib cut samples and for using the sample in determining the lean, fat, and bone percentages (70). There is also an indication that the 12th rib alone may be very satisfactory (38).

Creatinine excretion and the separable lean content of the 9, 10, 11th rib cut of 18 Hereford steers have been determined. The creatinine excretion per unit of body weight was significantly correlated with the percent separable lean in the soft tissue of the sample ($r = 0.67$). It was found that while there appeared to be little correlation between these two measures within carcass grades, the correlation between grades was good. Although the correlation coefficient is probably not high enough to enable one to predict small differences between individual animals, it does appear possible that creatinine excretion may be useful as an indication of differences in the lean content of the bodies of groups of animals differing by one or more slaughter grades (116).

The separable fat of the rib sample can be predicted accurately from the specific gravity of the whole sample by use of the equation:

$$F = \frac{1.155 - G_W}{0.261}$$

where F is the proportion of separable fat in the rib cut and G_W is the specific gravity of the whole cut.

Thirty head of yearling Hereford steers and heifers fed on two different planes of nutrition to produce wide variation in composition were compared. Specific gravity ranged from 1.017 to 1.070. Fat content varied from 13.6 to 39.5 percent of body weight (111).

Correlations

Body specific gravity/fat content	= -0.956
Body specific gravity/water content	= 0.984
Specific gravity of carcass/specific gravity whole animal	= 0.989
Specific gravity of carcass/specific gravity 9, 10, 11th rib cut	= 0.950
Specific gravity whole animal/specific gravity 9, 10, 11th rib cut	= 0.954

Based on the mean value of 72.6 percent water in the lean body mass of cattle, the following theoretical equations were derived showing the relationships between body specific gravity and body water and body fat:

$$\text{Percent fat} = 100\left(\frac{4.802}{\text{sp. gr.}} - 4.366\right)$$

$$\text{Percent water} = 100\left(3.896 - \frac{3.486}{\text{sp.gr}}\right)$$

Total body water calculated for 20 cattle by antipyrine technique was highly correlated, (.939) with total body water determined by analysis (174).

A rapid titrimetric method for determining the water content of human blood has been described (39). A small amount of blood is used and the determination is made in ten minutes. The method may be applicable to cattle.

Water content of psoas muscle, calculated on fat-free basis, is the same for cattle, lambs, and pigs, the average being about 78 percent (27).

Average water content of the combined muscular and fatty tissues of a carcass were the same for cattle and lambs, 79 percent (on a fat-free basis). Beef carcasses lose 2.5 percent of the original carcass weight during normal handling and storage. After this loss, the water content was calculated at 77 percent on a fat-free basis.

As growth and fattening proceed, the extra fat is partitioned unequally among the tissues. A larger and larger portion of fat goes to the fatty tissues and a smaller and smaller portion to the muscular tissues.

In a study with lambs, animals maintained on a high plane of nutrition had carcasses very similar to animals that had been maintained on a low nutritive plane and then put on adequate feed prior to slaughter.

The treatments actually caused greater difference on carcass measurements than on composition (138). In an experiment using identical twins, the effect of continuous and interrupted growth was studied (183). Between the ages of 6 and 12 months, one twin received a liberal ration while the co-twin received either maintenance, half-liberal, or 75 percent liberal ration. All animals were slaughtered at 1000 pounds. Although the retarded animals took longer to reach the slaughter weight, meat quality, or the proportion of lean meat as compared with fat and bone, was not affected. Other studies have indicated that the main effect of various planes of nutrition is in the amount of fat, and often age appears to be involved (75)(133).

Rapid fattening leads to the same level of fatness being reached at lower carcass weights than in the case of fattening at a slower rate. In carcasses containing more than 28 percent of fatty tissues, rapid fattening may be expected, at the same level of fatness, to produce carcasses with a slightly smaller percentage of bone than is the case with carcasses which have been fattened more slowly (29).

Major changes in the anatomy of carcasses and in the chemical composition of their tissues largely depend on the level of fatness of the carcass. Rate of fattening is responsible for most of the secondary differences.

As steers fatten, the proportions of rib, plate, rump, flank, and short loin, increase, those of foreshank, round, and loin end decrease, and chuck changes little (69).

Moisture and ash content of connective tissue decreases in cattle as the animal becomes older. The fat content of connective tissue was found to increase with the age of the animals (17).

As fattening proceeds, the weight of the carcass increases more and more rapidly for each increase in the percentage of fatty tissue. Thus, in the case of young steers, an increase from 20 percent to 25 percent increases the carcass weight by 100 pounds, whereas a further increase from 25 to 30 percent increases the carcass weight by 185 pounds. This accelerated increase of carcass weight is less marked the more rapid the rate of fattening (29).

As the carcass becomes heavier and hence fatter, the percentage of muscular tissue necessarily decreases. This decrease in the percentage of muscular tissue becomes progressively less as the carcass increases in weight. With young steers, an increase of 80 pounds in carcass weight occurs when the percentage of muscular tissue drops from 63 to 60 percent, whereas for the drop of 60 to 57 percent the carcass increases in weight by 140 pounds.

Young animals fatten more slowly than old ones and thus deposit less fat and more protein (30).

In steers over 2-1/2 years of age, 71.5 percent of the increase in carcass weight is due to chemical fat and only 4.45 percent to protein.

Cows fatten more slowly than old steers. With cows, only 58.2 percent of the increase in carcass weight is due to chemical fat, whereas 8.65 percent is due to protein. Cows thus deposit nearly twice as much protein in their carcass tissues as do steers during fattening (Table XIV)(26).

The carcasses of cattle and sheep fall into two groups, those containing less than 18 percent of fatty tissue and those containing more. It was suggested that animals with less than 18 percent of fatty tissue in the carcass are too young to have reached the fattening period of growth, while animals with over 18 percent of fatty tissue in the carcass are in the fattening period of growth (Table XV)(45).

The changes in the percentages of fatty tissue, muscular tissue, bone, tendons, etc., in the carcass can be expressed very accurately by equations (28).

A careful analysis was made of the carcasses from lean, half fat, and fat beef steers (Tables XVI, XVII, and XVIII)(44).

TABLE XIV

A Series of Carcass Weights for Cows, Old Steers, and Young Steers, together with Calculated Weights for Their Muscular Tissues, Fatty Tissues, and Bone (26)

Carcasses from	Carcass wt. (lbs.)	Fatty Tissue (lbs.)	Muscular Tissue (lbs.)	Bone etc. (lbs.)	Fatty Tissue %	Muscular Tissue %	Bone etc. %
Cows	518	93.17	319.83	105.0	18.0	61.7	20.3
	600	139.5	355.5	105.0	23.3	59.2	17.5
	700	196.0	399.0	105.0	28.0	57.0	15.0
	800	252.5	442.5	105.0	31.6	55.3	13.1
	900	309.0	486.0	105.0	34.3	54.0	11.7
Old steers	655	118.15	427.0	109.85	18.0	65.2	16.8
	700	151.0	436.0	113.0	21.6	62.3	16.1
	800	224.0	456.0	120.0	28.0	57.0	15.0
	900	297.0	476.0	127.0	33.0	52.9	14.1
	1000	370.0	496.0	134.0	37.0	49.6	13.4
Young steers	321	57.82	203.58	59.6	18.0	63.4	18.6
	350	70.0	217.5	62.5	20.0	62.1	17.9
	450	112.0	265.5	72.5	24.9	49.0	16.1
	550	154.0	313.5	82.5	28.0	57.0	15.0
	650	196.0	361.5	92.5	30.2	55.6	14.2
	750	238.0	409.5	102.5	31.7	54.6	13.7

TABLE XV

Percentage Lean, Visible Fat, and Bone (45)

	Immature Steer*			Mature Steer*		
	Lean	Fat	Bone	Lean	Fat	Bone
Forequarter	52.63	30.77	16.60	58.18	23.84	17.98
Hindquarter	56.30	31.66	12.04	51.87	34.92	13.21
Loin	59.83	30.31	9.86	61.53	25.05	13.42
Rib	51.95	33.33	14.72	51.87	30.14	17.99
Round	60.56	22.02	17.42	58.18	23.39	18.43
Chuck	57.93	25.54	16.55	66.82	15.23	17.96
Neck	68.34	16.58	15.08	64.35	27.00	8.65
Plate	40.44	48.28	11.28	44.81	40.84	14.35
Foreshank	48.89	16.36	34.75	51.46	14.07	34.47
Flank	55.04	44.96	-	42.69	55.97	1.34
Entire side	54.20	31.08	14.31	54.95	29.13	15.67

*Immature steer - Shorthorn, 12 months old, weighed 852 lbs.
*Mature steer - Hereford, 9 years old, weighed 1590 lbs.

TABLE XVI

Percent of Lean, Visible Fat, and Bone in Wholesale Cuts (44)

	Steer A			Steer B			Steer C		
	Lean	Fat	Bone	Lean	Fat	Bone	Lean	Fat	Bone
Loin	52.50	35.99	11.51	58.61	27.94	13.45	69.88	12.74	17.38
Rib	43.52	37.41	19.07	56.18	20.14	23.68	65.15	9.60	25.25
Round	58.83	19.66	21.51	75.85	14.68	19.47	69.26	7.60	23.14
Chuck	57.60	23.79	18.63	67.24	12.26	20.50	66.97	8.56	24.47
Plate	34.83	49.09	16.08	58.00	25.56	16.44	51.98	25.22	22.80
Flank	21.82	77.27	.91	35.30	64.70	-	46.38	50.72	2.90
Foreshank	48.74	12.56	38.70	46.60	7.77	45.63	50.00	3.64	46.36
Entire side	49.61	32.93	17.11	60.54	20.54	18.60	63.54	12.90	22.59

TABLE XVII

Summary of Carcass Data, Three Steers (44)

	A	B	C
Live weight	925	1070	1000
Percentage:			
Chilled carcass	61.4	57.76	52.00
Hide	8.0	7.57	7.1
Head	3.16	3.10	2.85
Forequarter	51.24	51.61	54.23
Hindquarter	48.76	48.39	45.77
Round	23.05	26.37	25.66
Loin	19.35	17.20	16.15
Rib	9.72	9.13	7.76
Flank	3.93	2.73	2.63
Plate	12.77	14.47	12.17
Chuck	21.91	21.77	24.11
Foreshank	3.57	3.31	4.18
Neck	3.10	3.44	5.63
Kidney knob	2.60	1.61	1.71

TABLE XVIII

Fuel Value of Wholesale Cuts (44)

	Steer A			Steer B			Steer C		
	% Fat	% Protein	Cal.*	% Fat	% Protein	Cal.*	% Fat	% Protein	Cal.*
Loin	43.19	9.94	1943	28.93	12.09	1418	15.43	14.32	890
Round	24.56	14.54	1266	13.76	14.62	827	9.22	14.50	639
Rib	40.29	7.94	1789	30.23	12.69	1364	15.38	12.78	660
Chuck	30.26	10.94	1434	14.72	14.46	854	11.45	13.65	715

*Cal. = calories per pound boneless meat.

Steer A = purebred Shorthorn steer. Fitted for show, but not carrying enough evenly distributed fat to grade prime. 17 months old.

Steer B = high grade Hereford, in half fat condition. 2 years old.

Steer C = Shorthorn of mediocre type. Thin but free from coarseness. 2 years old.

The proportion of muscle, fat, and bone has been shown to depend on the following factors:

1. Age of animal (61)(83).

2. Plane of nutrition (amount of external fat)(15)(46)(61)(65)(83)(168)(184).

3. There is no appreciable difference between steers and heifers of equal finish (46)(77)(83).

4. Exercise has no appreciable effect (23)(83).

5. There is no difference between "comprest" and "conventional" Hereford steers (124)(181).

6. The greatest difference between types and breeds of steers is primarily the quantity of fat deposited while the quantity of protein is roughly the same (83)(87)(88)(94)(126).

Dressed Carcass (126)

	Sep. Fat %	Sep. Lean %	Sep. Bone %
Beef breed	30.78	57.71	12.94
Dual-purpose	25.26	61.88	13.91
Dairy breed	29.54	57.63	13.92

Holstein Steers, Analysis of 1 Rib Section (129)

	Percent Bone	Percent Meat	Percent Water
Good	19.0	81.0	43.0
Commercial	28.2	71.8	59.3

7. Bred heifers, fed the same length of time as open heifers, showed a carcass composition of 20 percent more fat, 5 percent less lean, and 10 percent less bone than the open heifers (159).

8. There is no apparent effect of early and late castration on the carcass of animals slaughtered at early ages (99). The bulls were not as well finished as the steers when slaughtered. However, the meat was of comparable quality.

Effect of Age of Castration on Carcass Quality (99)

	Steers Castrated Early	Steers Castrated at Weaning	Bulls
Slaughter weight	853.9	848.8	916.2
Dressing percentage	60.9	61.2	59.8
Percentage forequarter	52.2	51.5	53.8
Percentage bone	15.4	15.6	16.2
Percentage fat	10.4	10.0	5.4
Percentage edible portion	73.70	74.10	77.70

9. Data analysis has shown a highly significant yearly variance in percent of fat in the rib cuts, whereas there were no statistically significant differences between sires (102).

Carcass Grade and Dressing Percentage

The carcass grade and dressing percentage has been considered an important measure of the final carcass value.

Buyers are unable to estimate carcass yield or carcass grade accurately, especially for individual steers or heifers. On individual animals they estimated one-half the cases 1.25 percent or more above or below the actual yield. The estimate of carcass grade for one-half of the cases was at least one-quarter of a full grade above or below the actual grade. The errors in estimating grade were more important than errors in yield in failure to price individual steers or heifers accurately (41).

Estimates of yield and carcass grade for veal calves by packer buyers were studied. Differences were found between plants, and in general results were not accurate (151).

Appraisals appeared to be as accurate as a grading committee in determining what appears to be desirable beef (121). Comparison of appraisal values with actual sales prices of the beef reveals a general correspondence, but occasional instances occur where the actual sales prices were far from corresponding to the value of the beef.

Data on 167 steers of Hereford, Shorthorn, Aberdeen-Angus, and dairy breeding were used to develop a method of determining slaughter grade by the use of height at withers and weight or heart girth (100).

The multiple curvilinear relationship was derived from the data:

$$\text{Grade} = -223.2839 - 3.5853\,(H) + 157.9825\,(\log W)$$

H is height at withers in inches
Log W is log of live weight in pounds

In another study with 325 cattle in which live weight and other characteristics varied widely, it appears that length in relation to width appeared promising as a subjective determination of carcass grade (66).

Steers increase more in width during fattening than they do in length or depth of body, and least of all in height and head measurements (119).

The possibility of defining quantitatively the carcasses of cattle has been investigated and a procedure evalued, based upon "conformation," "finish," and "quality," which are the features appraised by beef-carcass graders.

"Conformation" is determined by a series of ratios.

"Finish" is determined by a percentage assessment of the distribution of subcutaneous fat over the carcass.

"Quality" includes color of fat, firmness of fat, marbling and color of lean. Firmness of fat is related to iodine number. Degree of marbling is determined from the size relation of a petro-ether extract to a sample portion of the carcass taken at a defined situation (189).

Scoring as a technique of evaluation of differences of animals is subject to considerable error and is probably of very doubtful value when differences between animals are small. When the population to be studied shows large differences, the scoring technique is undoubtedly the simplest way to evaluate differences in conformation.

Slaughter tests have shown repeatedly that there are material differences between the progeny of two bulls, yet scores and grades have failed to show much difference (164).

From measurements taken on 258 steers with heart girths of 63 to 80 inches, the following formulas were derived (8):

1. Live weight in pounds:

   1.04 [(27.5458 x heart girth in inches) - 1049.67)]

2. Dressing percentage:

   44.08 - (.0029 x live weight in pounds) - (.1155 x height in cm) +

   (.2658 x heart girth in cm.) - (.0801 x paunch girth in cm.)

In a comparison of common, medium, good, choice, and prime carcass grades, it was found that as the grade increased: (a) the percentage of chuck, round, and neck decreased, and (b) the proportions of loin, flank, plate, brisket, ribs, and kidney knob increased (31)(133).

Factors Affecting Carcass Grade and Dressing Percentage:

1. Pregnancy in cattle, up to the fifth or sixth month, does not seriously affect the dressing percentage in reasonably well-finished heifers (74) (159).

2. Except that carcasses of bred heifers are noticeably better finished than those of open heifers, there was no significant difference in carcass grade (159).

3. There was no significant difference between early and late castration on the carcass. The bulls were not as well finished as the steers when slaughtered, but when based on market value the bulls yielded edible meat of comparable quality to steers (3)(99).

4. Dressing percentage of yearling and two-year-old heifers and steers varied little. In the case of calves, both open and spayed heifers dressed considerably more than steers (52).

5. Heifer carcasses graded equally as well as steer carcasses produced by similar methods of feeding (46).

6. With animals on full feed, heifers showed suitable market finish 30 to 40 days sooner than steers (166).

7. Based on selection at the time of being put on feed, rangy calves are equal or superior to low-set calves of the same quality in ability to gain in weight, in dressing percentage, and in carcass grade (89).

8. There is a significant difference in carcass grades between progeny groups of different sires (102)(148)(175).

9. Carcass grade is not affected by exercise (23).

10. Steers fattened on pasture alone had significantly lower dressing percentages and carcass grades than animals that had received grain (24) (168).

11. Animals that had been maintained on a low plane of nutrition during the winter, followed by summer grazing and dry-lot finishing, had lower grading carcasses and more variability than animals kept on a higher plane of nutrition during the winter (75).

12. Sucrose in varying amounts was fed to beef cattle 6 hours to 14 days prior to slaughter. Some levels of sucrose feeding resulted in increases in dressing percentages (55)(180).

13. A comparison of "small" type Herefords and Shorthorns compared to "large" type shows no consistent difference in dressing percentage or carcass grade (2)(108)(161)(165)(172).

14. Holstein steers that have been grown for beef appear to have very satisfactory carcasses (129)(149). The carcass grade for these steers is directly associated with their weight.

15. In a comparison of crossbred Angus-Holstein calves with Angus and Holstein calves for baby beef, the following results were obtained (47)(48):

	Angus-Holstein	Holstein	Angus
Average daily gain	2.05	2.37	2.19
Percent shrink	4.11	4.00	4.03
Percent dressed	62.00	59.03	62.07

The crossbred cattle produced carcasses almost as well suited to the beef trade as the Angus. Differences in color of fat and lean, marking of meat, and quality between Angus-Holstein and Angus carcasses were difficult to detect. In form, the Angus carcasses were preferable as they were shorter, appeared thicker, and the shanks were not as long as in the Angus-Holstein cattle.

16. In a comparison of Hereford, Shorthorn, and Hereford-Shorthorn crossbreds the crossbreds had a higher dressing percentage and carcass grade (101 (140).

17. In a comparison of the Hereford and Angus breeds and their reciprocal crosses all groups of calves from the Angus cows had a higher dressing percentage than corresponding groups of calves from the Hereford cows. The crossbreds from the Hereford cows had a slightly higher dressing percentage than the purebred calves from Angus cows.

    The crossbred calves, steers and heifers, from the Angus cows yielded the highest grading carcasses of all the groups, followed by the purebred Angus calves. The crossbred steers from the Hereford cows yielded higher grading carcasses than the purebred Hereford steers. The purebred Hereford heifers yielded higher grading carcasses than the crossbred heifers from the Hereford cows (50).

18. Carcass grade was improved when purebred Hereford or Angus bulls were used on native scrub cattle (43)(87).

19. Brahman crosses appear to have higher grading carcasses and higher dressing percentage than straight-bred Brahman or British cattle if the amount of Brahman breeding does not exceed 50 percent (5)(97)(107).

20. Final carcass grade was influenced by method of feeding to a much greater extent than feeder grade (9).

Organoleptic Tests

A detailed explanation of statistical methods applicable to flavor and aroma testing has been presented (85). It was concluded that statistical methods are needed to specify the repeatability of appraisals obtainable in the laboratory from small groups of subjects and to estimate population reactions from group reactions. Effective statistical analysis and estimation are currently limited primarily by ignorance of the frequency distributions actually operative in specific instances. Accumulation of factual information about these is essential to development of a logical discipline of subjective appraisal testing.

A summary of the various types of sensory tests concludes that there are many pitfalls in interpreting sensory difference data in terms of consumer acceptance (160). No precise methods of doing this have yet been perfected. The best we can do is to ascertain whether a product under test is different from one of known acceptance. This fact is often of considerable value in quality control work.

Types of Sensory Tests (160)

Identification Tests:

In these the panel member is asked to identify one of two different samples. The sample to be identified is a product with which the observer has had previous experience. The significance of the results may be determined by the chi square test or by means of the critical ratio.

Duo-trio Difference Test:

To determine sensory differences between a known food product and a test item. This type of test is well suited to detecting storage deterioration, formulation, manufacturing, and processing changes. The significance of the data obtained may be ascertained by chi square or critical ratio analysis. Probabilities also can be calculated by the binomial expansion theorem. The latter probably should be used where the number of judgments are fewer than 15 to 20.

Triangle Test:

Here three samples are presented. The panel member is asked to identify the odd sample. The data may be analyzed by chi square or critical ratio statistic or by the binomial expansion theorem.

Dual-standard Test:

This test is very similar to the duo-trio test, the difference being the existence of two identified standards (a control and a variant). The same pair, unidentified, are also presented to the panel. The observers are asked to identify the latter two. It is claimed that this test is especially suited for use in determining odor differences. The data are analyzed for significance exactly as for the duo-trio test.

Dilution Test:

This test measures the smallest quantity of an unknown material which may be detected by sensory methods when diluted into a control sample of the same material.

Scoring Tests:

In these tests, the panel member attempts to assign a score to a single quality or a composite quality of a product.

Ranking Tests:

These tests require of the panel member the simple ranking, in decreasing or increasing order, of some characteristic or the over-all characteristic of the product in question.

Consumer Preference Studies

In an analysis of the demand for meat, it was concluded that the consumer panel technique is a workable method for collecting data at the household level with limited research resources (18). A panel consisting of 250 families who report each week in detail on their food purchases does show considerable potential as a means of securing data for demand analysis and related subjects. In a survey among householders in St. Louis, it was found that 83 percent of the shoppers were women and 14 percent were husbands (158). Of these shoppers, 48 percent preferred self-service, 36 percent preferred a butcher and 14 percent indicated no preference. A study in the Michigan area showed that stores which converted to prepackaged meat merchandising sold more meat than before they converted, and also increased their meat sales relative to the butcher-service meat stores. Stores which retailed prepackaged meats had an increase in total store sales. Having prepackaged meat seemed to attract more customers to the stores (110).

A consumer preference study in Washington showed the following points (130):

1. No particular preference for federally graded or packer branded beef.

2. Consumers preferred medium-colored lean and had a slight preference for light color over dark.

3. Consumers do not object to yellow-fatted beef.

4. U. S. Choice, U. S. Good, and U. S. Commercial chucks and short loins were cut into retail cuts. All three grades were uniformly cut and priced the same per pound. The consumers preferred the leaner, lower quality grades of beef.

A Canadian report on the influence of prices on the relative consumption of beef and pork for the years 1927-1950 showed that 90 percent of the variation in consumption of beef expressed as a percentage of consumption of pork was associated with variation in the price of beef expressed as a percentage of the price of pork.

A one percent change in the price of beef relative to that of pork resulted in a one percent change in the opposite direction in the consumption of beef relative to that of pork (186).

Quality

Quality has been defined as that which the public likes best (64). Quality then, would include texture, tenderness, color of meat, color of fat, amount of fat and marbling, and flavor of meat and fat.

In terms of general, over-all quality, the following conclusions have been made:

1. Steers and heifers have meat that is comparable in firmness of fat, color of lean, and palatability of cooked beef (22)(46)(77)(166).

2. Bulls and steers 11 to 16 months old were compared (177). Although meat from bulls was somewhat less tender by comparison with that from steers, it was quite acceptable.

3. While exercise is expensive from the standpoint of feed cost, the amount of walking required of cattle even on scant pasture does not have a detrimental effect on the quality of beef. On the contrary, it appears that heavy exercise makes beef more tender (23).

4. There is a close connection between the fatness of the meat and its palatability when roasted. Up to the point at which rather more than one-third of the piece is fatty tissue the palatability is enhanced as the fatness increases. Beyond this point, the palatability diminishes. It appears that animals dressing out 58 percent provide beef at optimum stage of fatness for maximum palatability (26).

5. Ten yearling steers were fed by paired-feeding method on high and low levels of phosphorus (58).

   a. Rib roasts from the high-phosphorus steers were judged higher grade in tenderness, desirability of flavor of lean, quality of juiciness, desirability of aroma, intensity of flavor of fat, and texture.

   b. After ripening 28 days, rib cuts from the high-phosphorus steers suffered less spoilage and lower shrinkage losses.

   c. Phosphorus-deficient beef was inferior to high-phosphorus beef in palatability, keeping quality, and shrinkage loss.

6. The plane of nutrition during the wintering period prior to fattening does not appear to have any appreciable effect on meat quality (11)(75)(183).

7. While fattening, the more rapidly gaining lots have meat that is generally more tender and palatable (15)(24)(125)(168), although exceptions also have been noted (65)(174). Actually, the differences appear to be very small and may be confounded with age (19).

8. There appear to be small but real differences in the meat quality between beef breeds and scrub or dairy cattle (82)(139)(150), although exceptions are reported (87)(92)(93).

9. Including such items as sucrose, beef fat, molasses, and diethylstilbestrol in cattle rations does not appear to have an appreciable effect on meat quality (25)(55)(78)(173)(180).

Tenderness and Flavor

Beef quality is markedly affected by tenderness and flavor. Flavor is a somewhat subjective measure, but tenderness can be considered as more objective.

Nine samples of muscle from each of 52 animals that varied widely in age were studied (70). The findings showed more elastic fibers in the active muscles and fewer in the less used ones. Larger amounts of collagenous fibers were found again in those muscles which were used more extensively. In muscles with fatty deposits there was more of a loose network between muscle bundles; while in those with less fat the bundles appeared bunched. These findings agreed closely with the tenderness of the beef muscle.

Lean meat is essentially muscle tissue, but it contains considerable and variable amounts of connective tissue. It is the connective tissue fibers, rather than the muscle fibers, to which the greater portion of the toughness of meat is due (131).

Connective tissue fibers consist of two proteins, collagen and elastin.

1. No constant and significant differences in connective tissue content were found between heifer and steer beef.

2. In retail cuts, the order of increasing collagen content was as follows: rib eye muscle, tenderloin, inner round, outer round, porterhouse, sirloin, chuck, ribs, navel, foreshank.

3. Age does not seem to have a great deal of effect upon the connective tissue content of muscle meat, nor a consistent effect among the different muscles of the carcass.

Collagen and elastin content of longissimus dorsi of beef animals is not a critical measure of tenderness of meats (182). Tenderness of U. S. Choice (new grade) beef muscles was determined by (a) shearing raw and cooked muscles, (b) organoleptic tests on cooked muscles and (c) histological examination (145). The results were as follows:

1. There is variation in tenderness in different regions of the same muscle.

2. There is variation in tenderness of different muscles within standard cuts.

3. There is correlation between shear readings and amounts of collagen and elastin in the muscle.

4. There is correlation between organoleptic tests and the amount of collagen and elastin in the muscle.

The Bratzler-Warner Shear has been used as a mechanical test of tenderness. There is doubt, however, that the machine is accurate enough to be used as a criterion (91). In another possible measure of tenderness, a single muscle fiber was stretched to the breaking point. This extensibility is apparently not associated with tenderness except in specific instances (169).

Variations in pH, protein, fat, and moisture content were present for different muscles but did not correlate with tenderness values of the muscles (163). The short loins were studied from a group of 20 animals representing wide variations in market grade (92)(93). Carcass score and intramuscular fat were associated with tenderness while alkali-insoluble protein showed a negative relationship.

Thawing temperatures do not affect press fluid, drip, total moisture, or tenderness. Frozen beef had significantly greater total losses than unfrozen and significantly less press fluid. Differences for drip, total moisture, and tenderness were not significant (33).

Beef was more tender at two hours following slaughter than at any time thereafter for the next two to six days. By the twelfth day after slaughter it was more tender than it was two hours after slaughter (143)(144).

Muscle plasma proteins are closely related to tenderness and shrink in meat. (179). Post-mortem formation of actomyosin seems to be related to the initial toughening of meat. Post-mortem changes in ion protein interrelations may account for tenderization on aging. Shrinkage and drip may also be related to these ion protein interactions.

Short loins are less tender at the rib end than at the porter house steak end. Analysis of variance shows a highly significant difference between two-day aged beef and that aged longer, between grades, and between aged and aged frozen samples (12). In a study of animals 2-1/2 months to 5-1/2 years, less difference in tenderness was found between samples representing veal or 500-pound calves than in those from older, more mature animals. As age of the animals increased, tenderness decreased. The difference between veal and beef from 500-pound steer calves was not statistically significant (81).

In histological observations on fat loci and distribution in cooked beef, it was noted that as steaks were broiled the released fat showed a progressive dispersion along the path of hydrolyzed collagen with the resulting fat droplets thoroughly mixed with the latter (170). However, it has been determined that variations in tenderness of meat are caused mainly by factors other than fatness (69).

In a rather complete study of factors affecting flavor of meat, the following conclusions were obtained (39):

a. In raw meat the small amount of blood-like flavor present resides in the juice only and not in the fiber.

b. No enzyme appeared to exist in the saliva capable of hydrolyzing raw meat fiber to release any taste-producing substances during chewing.

c. Cooking developed meaty flavor, apparently owing to chemical changes taking place in the fiber rather than in the juices.

d. This meaty flavor, typical of cold roast beef, was apparently due to volatile substances detected by the sense of smell, even though chewing was needed to release it. It was fragrant, moderately acidic, only slightly burnt, and distinctly caprylic. It was definitely sulfury.

There are no apparent differences between breeds of a species as far as flavor of meat is concerned (83). Bull meat is stronger than steer, but there is no difference between heifers and steers.

Data on 97 beef rib samples indicated the percentage of press fluid was not significantly related to scores for quantity of juice. Apparently with an increase in percentage of fat in the press fluid as the result of more intramuscular fat, there was a tendency for the percentage of press fluid to decrease, and the scores for quantity and quality of juice to increase (49).

Color of Meat:

Black beef appears to be the result of some undetermined factor affecting the condition of the muscle hemoglobin rather than the quantity of hemoglobin present (123).

Abnormal feeding, exposure, and improper handling tend to produce dark-cutting beef. Low muscle sugar and high pH have been found to be characteristic (114) (115).

There is no distinct breed effect, although higher condition does produce lighter colored beef (83). Beef reaches an optimum color between one and two years of age. There is no difference between steers and heifers, but bulls are darker than steers or cows. Feed, method of killing, and exercise do not seem to be important.

A study of the relationships of flavor and juiciness of beef to fatness and other factors produced the following results (6).

Desirability of flavor of lean:

Factor	Percent of Variability
Fat	41
Age	26
Breeding	24
Sex	9

Desirability of flavor of fat:

Factor	Percent of Variability
Age	62
Breeding	25
Fat	9
Sex	4

Animals under 11 months of age had the least desirable fat.

Quality of Juice:

Factor	Percent of Variability
Age	39
Fat	35
Breeding	25
Sex	1

Chemical Composition

General analysis of cattle has included ash, water, protein, fat, and dry matter.

TABLE XIX

Composition of Entire Bodies of Cattle (4)

Age	Condition	Percentage Composition - Empty Body Weight				
		Ash	Protein	Fat	Dry Matter	Water
9 to 10 weeks	fat	3.9	15.9	15.3	34.9	65.1
4 years	half-fat	5.0	18.4	20.8	43.9	56.1
4 years	fat	4.2	15.4	32.0	51.6	48.4
2 years	-	4.4	17.4	18.8	40.6	59.4
33 months	-	5.1	16.6	25.2	46.9	53.1

TABLE XX

Composition of Fat- and Ash-Free Lean Meat of Cattle (4)

	Percent
Carbon	52.54
Hydrogen	7.14
Nitrogen	16.67
Sulphur	0.52
Oxygen	23.12

TABLE XXI

Composition of Steers at Various Ages - Empty Weight (4)

Normal Weight (lbs.)	Water %	Dry Matter %	Protein %	Fat %	Ash %
100	71.85	28.15	19.90	3.99	4.26
200	69.47	30.53	19.63	6.26	4.64
300	66.31	33.69	19.35	9.84	4.50
400	65.76	34.24	19.31	10.56	4.37
500	62.91	37.09	19.15	13.73	4.21
600	62.21	37.79	19.22	13.97	4.60
700	60.75	39.25	18.83	15.91	4.51
800	57.88	42.12	18.69	19.23	4.20
900	54.09	45.90	17.66	24.08	4.16
1000	53.09	46.91	17.57	25.53	3.81
1100	48.02	51.98	16.19	31.91	3.88
1200	48.64	51.36	15.66	31.10	3.67

TABLE XXII

Proximate Composition of Meat (32)

AP--as purchased, EP--edible portion

Description	Basis	As Purchased Refuse	Water	Protein	Fat	Ash	Fuel Value Per 100 g.	Fuel Value Per Pound
Beef:								
Carcass:								
Thin: EP 86% lean	EP		66	18.8	14	.97	201	910
AP 70% lean	AP	19	54	15.2	11	.8	163	740
Medium:								
EP 79% lean	EP		60	17.5	22	.87	268	1,220
AP 66% lean	AP	16	50	14.7	18	.7	225	1,020
Fat: EP 73% lean	EP		55	16.3	28	.79	317	1,440
AP 62% lean	AP	15	47	13.9	24	.7	270	1,220
Very fat:								
EP 62% lean	EP		47	13.7	39	.65	406	1,840
AP 55% lean	AP	12	41	12.1	34	.6	357	1,620

Table XXII (continued)

Wholesale Cuts:

<u>Chuck</u>:									
Thin:	EP 92% lean	EP		71	19.2	9	.94	158	720
	AP 75% lean	AP	19	57	15.6	7	.8	128	580
Medium:	EP 87% lean	EP		65	18.6	16	.88	218	990
	AP 72% lean	AP	17	54	15.4	13	.7	181	820
Fat:	EP 83% lean	EP		60	17.6	22	.82	268	1,220
	AP 71% lean	AP	15	51	15.0	19.0	.7	228	1,030
Very Fat:	EP 76% lean	EP		52	15.0	32	.74	348	1,580
	AP 66% lean	AP	13	45	13.0	28	.6	303	1,370
<u>Flank</u>:									
Thin:	EP 60% lean	EP		52	17.0	30	.77	338	1,530
	AP 59% lean	AP	1	52	16.8	30	.76	335	1,520
Medium:	EP 51% lean	EP		45	14.6	40	.74	418	1,900
	AP 50% lean	AP	1	44	14.5	40	.63	414	1,880
Fat:	EP 44% lean	EP		39	12.7	48	.54	483	2,190
	AP 44% lean	AP	1	39	12.6	48	.53	478	2,170
<u>Loin</u> (excluding kidney knob):									
Thin:	EP 85% lean	EP		64	18.6	16	.95	218	990
	AP 71% lean	AP	16	54	15.6	13	.8	183	830
Medium:	EP 76% lean	EP		57	16.9	25	.84	293	1,330
	AP 65% lean	AP	14	49	14.5	22	.7	252	1,140
Fat:	EP 70% lean	EP		53	15.6	31	.77	341	1,550
	AP 62% lean	AP	12	46	13.7	27	.7	300	1,360
Very fat:	EP 59% lean	EP		44	12.8	43	.62	438	1,990
	AP 53% lean	AP	10	39	11.5	39	.7	394	1,790
<u>Plate and Brisket</u>:									
Thin:	EP 83% lean	EP		60	17.9	21	.87	261	1,180
	AP 65% lean	AP	22	47	14	16	.7	203	920
Medium:	EP 73% lean	EP		53	15.8	30	.75	333	1,510
	AP 60% lean	AP	18	44	13.0	25	.6	273	1,240
Fat:	EP 66% lean	EP		47	14	38	.65	398	1,810
	AP 56% lean	AP	15	40	11.9	32	.7	338	1,530
Very fat:	EP 53% lean	EP		38	11.0	51	.48	503	2,280
	AP 47% lean	AP	11	33	9.8	45	.4	448	2,030

Table XXII (continued)

Rib:										
Thin:	EP 92% lean	EP		66	19.0	14	.94	202	920
	AP 69% lean	AP	25	50	14.2	10	.7	152	690
Medium:	EP 82% lean	EP		59	17.4	23	.83	277	1,250
	AP 65% lean	AP	21	46	13.7	18	.7	219	990
Fat:	EP 76% lean	EP		52	15.8	31	.74	342	1,550
	AP 62% lean	AP	18	43	13.0	25	.6	281	1,270
Very fat:	EP 62% lean	EP		43	12.7	44	.59	447	2,030
	AP 53% lean	AP	14	37	10.9	38	.5	384	1,740
Round:									
Thin:	EP 92% lean	EP		71	19.7	8	1.0	151	680
	AP 81% lean	AP	12	63	17.3	7	.9	133	600
Medium:	EP 87% lean	EP		67	19.3	13	.95	194	880
	AP 77% lean	AP	11	59	17.2	12	.8	173	780
Fat:	EP 84% lean	EP		63	18.7	17	.90	228	1,030
	AP 76% lean	AP	10	57	16.8	15	.8	205	930
Very fat:	EP 78% lean	EP		58	17.4	24	.82	286	1,300
	AP 71% lean	AP	9	53	15.8	22	.7	260	1,180
Rump:									
Thin:	EP 75% lean	EP		60	17.4	22	.88	268	1,210
	AP 55% lean	AP	27	44	12.7	16	.6	195	890
Medium:	EP 67% lean	EP		53	15.5	31	.77	341	1,550
	AP 51% lean	AP	24	40	11.8	24	.7	259	1,180
Fat:	EP 61% lean	EP		48	14.2	37	.69	390	1,770
	AP 48% lean	AP	22	38	11.1	29	.5	304	1,380
Very fat:	EP 50% lean	EP		40	11.4	48	.56	478	2,170
	AP 40% lean	AP	19	32	9.2	39	.5	387	1,750
Beef Brains	EP			77.9	10.5	8.8	1.4	127	580
Beef Liver	EP			69.7	19.7	3.2	1.4	132	600
Beef Lungs	EP			78.8	17.6	1.0	0	92	420
Beef Tongue	EP			68	16.4	15	.86	202	920

Several lines of indirect evidence indicate a constancy in gross composition of the fat-free body (141). In fact, it has been stated that the chemical composition of the bodies of farm animals is determined when the percentage of fat is known, for the composition of the non-fatty matter is practically the same in all and is not affected by fatness and varies only to a slight extent with age (135).

	Ash	Percentage Protein	Water
Young, growing animals	4	20	76
Adults	6	22	72

The veal is higher in moisture and ash than U. S. Good beef and Utility cow beef (16).

Ash is not greatly affected by age or plane of nutrition. Total phosphorus of lean samples shows no significant effect of age or varied plane of nutrition.

The percent of phosphorus is higher in the lean flesh than in the fatty tissue (149).

"Prediction" tables have been set up whereby if the body weight is known the organ weight may be estimated from the tables (20).

TABLE XXIII

The Alanine, Cystine, Glycine, and Serine Content of Meat (1)

Cut of Meat	Percent Crude Protein	Analysis (Grams per 100 gm. of Protein (calculated to 16% N)			
		Alanine	Cystine	Glycine	Serine
Veal:					
Round	82.9	6.3	1.0	4.6	4.7
Shoulder	85.3	6.1	1.0	4.6	4.5
Beef:					
Round	86.9	6.2	0.9	4.5	4.3
Shoulder	84.7	6.4	0.9	4.6	4.5
Brain	70.3	6.3	1.3	4.0	6.4
Heart	78.7	6.7	1.0	4.8	4.8
Kidney	79.7	6.2	1.3	6.2	5.4
Liver	67.7	6.3	1.0	5.9	5.5
Tongue	83.2	6.6	1.2	6.5	5.1

TABLE XXIV

The Amino Acid Composition of Meat (122)

Protein Content of Fresh Meat
(average values)

Kind of Meat	Crude Protein
Beef loin	21.65
Beef brisket	20.48
Beef round	20.96
Pork loin	20.53
Lamb chop	19.67
Beef liver	18.40
Beef heart	17.74
Beef kidney	17.76
Beef brain	10.65

TABLE XXV

The Amino Acid Composition of Meat (122)

Amino Acid in Crude Protein (percent)	Kind of Meat		
	Beef Muscle	Pork Muscle	Lamb Muscle
Arginine	6.2	6.4	6.2
Cistidine	3.7	3.8	2.1
Lysine	9.1	8.7	8.8
Tryptophan	1.2	1.2	1.2
Phenylaline	4.2	4.2	4.3
Threonine	4.5	4.5	4.8
Methionine	2.5	2.4	2.4
Valine	5.3	5.4	5.4
Leucine	8.6	8.6	8.5
Isoleucine	5.2	5.1	4.8

Variations in the amino acid content of samples of the same kind of meat taken from different animals were in almost all cases very small.

TABLE XXVI

Biotin Content of Beef Meat Samples (155)

Beef	mμg./gm. Fresh	Dry
Kidney	923	4050
Liver	1000	4000
Heart	75	400
Round	34	144
Rib	34	124
Pancreas	137	596
Spleen		245
Lung	59	290
Brain	61	288
Tongue	33	119

TABLE XXVII

The Riboflavin Content of Beef Muscle (14)

Average Value for Wholesale Cuts	Gamma Per Gram
Prime rib	1.7
Chuck	1.8
Round	1.6
Short loin	1.8

No relationship was shown between average daily gain, riboflavin intake per cwt. of gain, or carcass finish. Length of feeding period shows a relationship.

TABLE XXVIII

Amino Acid Composition of Meat (154)

	Percentage in Crude Protein of:					
	Leucine	Valine	Isoleucine	Methionine	Phenylalanine	Threonine
Beef:						
Muscle	8.4	5.7	5.1	2.3	4.0	4.0
Organ	9.1	6.0	5.1	2.1	4.8	4.7

	Arginine	Histidine	Lycine	Tryptophan
Muscle	6.6	2.9	8.4	1.10
Organ	6.0	2.5	8.3	1.34

The short loins were analyzed from a group of 20 animals representing wide variations in market grade (92)(93).

Alkali-insoluble protein (wet basis) 0.074 - 0.325
Intramuscular fat (%) 1.21 - 12.09
Moisture 66.96 - 76.81
pH 5.38 - 5.60
Total N 14.63 - 15.60
Trichloracetic acid soluble nitrogen 1.74 - 3.34
Non-protein nitrogen 1.01 - 1.86
Water soluble and heat coagulable nitrogen 1.14 - 3.61

The connective tissue (alkali insoluble proteins) of the longissimus dorsi muscle of cattle was found to be 12.39 percent hydroxyproline and to consist of 84 percent collagen and 16 percent elastin (178). The tyrosine and tryptophan content of the longissimus dorsi muscle of cattle was found to be relatively constant, 1.024 percent and 0.33 percent, respectively.

In cattle tissue, including lung, achilles tendon, ligamentum nuchae, trachael cartilage, and bone matrix, isolated carbohydrate-containing materials have been found that are distinct from acid mucopolysaccharides. They invariably contain galactose, mannose, and fructose, but are free from glucuronic acid (51).

TABLE XXIX

The Distribution of P^{32} in Tissues of a Steer (157)

(The following tissues were found to have the indicated values for percent dose of the isotope per 100 grams of the sample.)

Femur	0.06	Gall bladder	0.01
Rib	0.09	Heart	0.25
Vertebra	0.24	Kidney	0.41
Whole blood	0.05	Liver	1.95
Washed blood cells	0.03	Lungs	1.18
Adrenals	0.03	Pancreas	0.16
Bile	0.12	Spleen	0.30
Bladder	0.02	Salivary glands, thyroid, hair and hide	0.00
Brain	0.01		

When the collagen of hide is completely removed by autoclaving or treatment with acid, the membrane of the grain surface remains, along with a filmy network of tissue derived from the lower layers of the skin. The reticular material can be teased off, leaving a continuous sheet of grain membrane.

Even though there is a great difference in thickness between calfskin and cattle hide, the yield of grain membrane is essentially the same per unit area of the skin. In general, 1.0 mg. dry weight of grain membrane is obtained per square centimeter of the original skin.

The properties of the isolated grain membrane of cattle hide appear to be very close to those of elastin (84).

TABLE XXX

Composition of the Horn of a Cow (4)

Carbon	51.03 percent
Hydrogen	6.80 percent
Nitrogen	16.24 percent
Oxygen	22.51 percent
Sulphur	3.42 percent

The plasma and blood volumes were determined in the cow by the T-1824 hematocrit method (146).

Non-pregnant, non-lactating cows:

Plasma: 35 to 40 cc. per kg. body weight
Blood: 49.6 to 60.6 cc. per kg. body weight

Bovine plasma and blood volumes per unit weight are significantly lower than for rats, rabbits, dogs, sheep, and man.

In another study, the blood was determined with P^{32} (73).

TABLE XXXI

Age	Weight (pounds)	Ml. blood per 100 Gm. Body Weight: Mean	Std. Error
2-6 days	60	12.0	-
3 weeks	108	8.5	-
2-3 weeks	243	6.2	0.3
6-8 months	544	5.8	0.3
14-15 months	747	5.7	0.5
8-12 years	1045	5.7	0.4

1. Newborn of all species demonstrated a high blood volume

2. Blood volume values for cattle over 2 to 3 months of age showed no effect of age or weight

A number of methods for determining water content or retention in cattle have been determined. The estimation of water retention from the retention of sodium and potassium has been described (13). Analysis of the tissues of foetal, young, and mature cattle showed that their water content could be predicted from the equation:

$$\text{Water (gm)} = 0.2922\ \text{Na(mgm.)} + 0.1471\ \text{K(mgm.)}$$

Sodium thiocyanate has been used as an intravenous injection to determine total body water, cell mass, and body fat (128). Radioactive urea also can be used to measure total body water since only a negligible amount of urea is lost after administration (109). A rapid titrimetric method for determining the water content of animal tissues has been described (36). Blood and solid materials (100 to 250 mg. of material) can be used. The method agrees with oven drying. A modification of this test that requires only ten minutes and is accurate to within one percent compared to oven dried samples also has been outlined (39).

A method for determining the body water content of cattle by dilution of antipyrine administered intravenously has been described (112). Body water content on 30 head of cattle ranged from 43.9 to 63.3 percent, corresponding to a range in body fat of 13.9 to 40.1 percent. It has been pointed out that technique is very important in the antipyrine test (7).

In work with humans, a comparison of antipyrine and deuterium oxide methods for determination of total body water showed that the deuterium volume was uniformly greater than the antipyrine volume. Both methods reflected changes that agreed well with observed weight losses, but the deuterium method was considered more accurate (90). P^{32} and I^{131} have been used successfully for blood volume studies of man and laboratory animals. In applying these techniques to domestic animals, a number of modifications are necessary because of special variations in the rate at which labeled phosphate enters the red cells (96).

The relative efficiency of different types of cattle or systems of production cannot be accurately compared without considering the adaptability of the beef to the purpose for which it is used.

TABLE XXXII

Summary of Carcass Analysis and Fuel Value of Steers (59)

Wholesale Cut	Proportion %	Lean %	Fat %	Bone %	Water %	Protein %	Calories in 100 gm. boneless meat
Loin	16.76	58.53	31.75	8.89	47.42	12.96	396.8
Rib	9.77	55.21	30.17	14.18	45.15	12.32	419.7
Round	21.78	64.61	18.03	16.63	60.86	16.50	250.5
Chuck	21.89	69.47	18.63	11.26	56.32	14.87	313.7
Plate	15.63	50.61	40.73	8.47	39.42	10.59	483.1
Flank	5.15	36.30	63.18	.25	32.26	9.44	554.9
Foreshank	4.97	47.61	11.63	40.20	60.95	16.98	253.7
Kidney suet	4.06	7.01	92.99	0	-	-	-

Canning caused a slight but significant lowering in biological value of the beef protein. Roasting and corning did not change the biological value of digestibility (127). Beef round from grass-fed and grain-fed animals had similar biological and digestibility values. Average biological value of protein from raw beef round is 73 percent to 86 percent. Digestibility is 98 percent.

Perhaps the tocopheral requirements of milk- and meat-producing animals should be judged on the basis of the amounts needed to impart desirable nutritional stability to the products used as food rather than the smaller amounts which will prevent the onset of gross pathological changes (118).

The amount of vitamin A in the livers of steers fed alfalfa was greater than in the livers of soybean-fed steers (79).

Heritability Estimates

Item	Heritability	Reference
Carcass grade	57	(40)
Dressing percentage	70	(40)
Shrink	91	(156)
Dressing percentage	73	(156)
Carcass grade	16	(156)
Color of eye	31	(156)
Area of eye	72	(156)
Thickness of fat	38	(156)
Carcass grade	84	(106)
Area of eye	69	(106)
Dressing percentage	1	(106)
Carcass grade	52	(153)
Dressing percentage	39	(153)
Carcass grade	33	(105)
Area of eye	68	(105)
Organoleptic score	14	(188)
Shear value	19	(188)

Correlations

Carcass grade with:

Score at weaning	+.20*	(102)
Slaughter steer grade	+.55**	(102)
Birth weight	-.07	(184)
Weaning weight	+.43*	(184)
Efficiency of gain	+.03	(184)
Slaughter grade	+.52*	(184)
Area of eye	+.23*	(184)
Thickness of fat	+.54*	(184)
Dressing percentage	+.45*	(184)
Length of body	+.09	(184)
Length of leg	+.08	(184)
Gain on test	+.43	(184)
Efficiency of gain	+.02	(187)
Gain on test	+.08	(187)
Birth weight	-.18*	(187)
Thickness of fat over eye	-.72	(34)
Length (within weight group)	+.71	(34)
Weight	-.67	(34)
Length of loin	+.54	(34)
Width of shoulder	-.40	(34)
Width of round	-.30	(34)
Depth of body	+.30	(34)
Circumference of round	-.20	(34)
Rib eye area	-.10	(34)
Ratio weight/length	-.78	(34)
Circumference round divided by length of leg	-.48	(34)
Final feed-lot weight	+.54**	(106)
Rate of gain	+.37	(67)
Slaughter grade	+.86	(67)
Thickness of external fat	+.90	(67)
Thickness of flesh	+.90	(67)
Width of carcass	+.90	(67)

Item	Correlations	Reference
Feeder grade	+.69	(67)
Total gain	+.66	(67)
Rate of gain	+.37	(68)
Tenderness	+.66	(92)(93)
Calf grade	+.02	(42)
Yearling gain	+.02	(42)
Yearling grade	+.11*	(42)
Feed lot gain	+.35**	(42)
Fat grade	+.46**	(42)
Dressing percentage with:		
Efficiency of gain	-.24**	(187)
Gain on test	-.09	(187)
Birth weight	-.13	(187)
Gain on test	-.01	(184)
Efficiency of gain	-.23*	(184)
Slaughter grade	+.38*	(184)
Final weight	+.25*	(184)
Carcass grade	+.45*	(184)
Length of body	+.21*	(184)
Length of leg	+.16*	(184)
Area of eye	+.36	(184)
Thickness of fat	+.25	(184)
Height at withers	-.50	(10)
Height of floor of chest	-.46	(10)
Depth of chest	-.39	(10)
Length of body	-.49	(10)
Width of shoulder	+.38	(10)
Width of chest	+.50	(10)
Gain on test	-.32*	(164)
Area of eye muscle with:		
Final feed lot weight	+.14	(106)
Carcass grade	-.10	(34)
Birth weight	+.28*	(184)
Weaning weight	+.32*	(184)
Gain on test	+.36*	(184)
Efficiency of gain	+.07	(184)
Slaughter grade	+.29*	(184)
Carcass grade	+.23*	(184)
Length of body	+.38*	(184)
Length of leg	+.42*	(184)
Thickness of fat	+.01	(184)
Dressing percentage	+.36	(184)
Color of lean	-.03	(184)
Thickness of fat over eye with:		
Birth weight	-.09	(184)
Weaning weight	+.26*	(184)
Gain on test	-.07	(184)
Efficiency of gain	-.03	(184)
Slaughter grade	+.50*	(184)
Carcass grade	+.54*	(184)
Length of body	+.09	(184)

Item	Correlations	Reference
Length of leg	+.04	(184)
Area eye muscle	+.01	(184)
Dressing percentage	+.31*	(184)
Shipping shrink	+.17*	(184)
Color of lean	-.12*	(184)
Color of lean with:		
Birth weight	+.08	(184)
Weaning weight	+.13	(184)
Gain on test	-.13*	(184)
Efficiency of gain	-.14*	(184)
Slaughter grade	+.17*	(184)
Carcass grade	+.27*	(184)
Area of eye muscle	-.03	(184)
Thickness of fat	-.12*	
Muscle-bone ratio with:		
Length of hind leg	-.07	(71)
Length of body/empty body weight	-.27	(71)
Height at withers	+.13	(71)
Heart girth	+.13	(71)
Circumference of cannon bone	-.26	(71)
Width of chest	-.06	(71)
Efficiency of gain	-.04	(71)
Other correlations:		
Average daily gain/percent round	+.34**	(164)
Average daily gain/percent loin	+.36**	(164)
TDN for 100 lbs. gain/percent forequarter	+.71**	(164)
Height at withers/percent forequarter	+.54**	(164)
Depth of chest/percent hindquarter	-.36**	(164)
Depth of chest/percent loin	-.35**	(164)
Heart girth/percent hindquarter	-.65**	(164)
Heart girth/percent loin	-.31**	(164)
Tenderness/alkali-insoluble protein	-.88	(92)(93)
Tenderness/intramuscular fat	+.47	(92)(93)

General Statements and Observations

(a) The most important measurements for high dressing percent and meat value are a large heart girth in connection with a shallow chest, a wide loin, large flank girth, large initial weight, small paunch girth, head narrow at the eyes, and short height over hips (120).

(b) Correlations between muscle-bone ratio and live animal measurements gave little indication that conformation of the live animal could be used to predict this characteristic (71).

(c) There is a very high positive correlation between the organ weights and the weights of the empty-body and the lean-body mass. All visceral organs studied were about equally reliable in their predictive value. For a population limited in age and weight, the liver appears to be a better indicator than the other organs (113).

(d) Animals with a greater proportion of forequarter are less efficient animals (164).

(e) Calves weighing above the yearly average at birth made a more rapid growth before and after weaning, but birth weight had no effect on carcass quality.(132)(185).

(f) Differences in weaning weight had no apparent effect upon the carcass appraisals that followed a 250-day feeding period. It was possible to select for heavier weaning weights without sacrificing fleshing qualities.(185).

(g) Rapid gain in the feed lot was associated with a higher percentage of lean meat but may be correlated with less external fat (185).

(h) The ability to make rapid growth had little relationship with fleshing qualities (185).

(i) Slightly higher grading carcasses were associated with more rapid gains in the feed lot when equal total gains are made (68).

(j) Steers of shorter height both at the withers and at the floor of chest, and steers that were shorter in length of body, tended to have a slightly higher slaughter and carcass grade and a higher dressing percentage than more rangy steers (35).

(k) Steers with a large circumference of foreflank tended to make slightly higher slaughter grades. Also, steers wide in the shoulder made higher grades(35).

(l) Steers that had higher average daily gains tended to have higher carcass grades (35).

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