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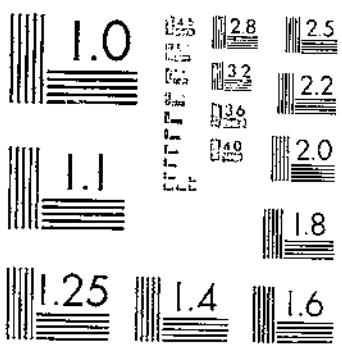

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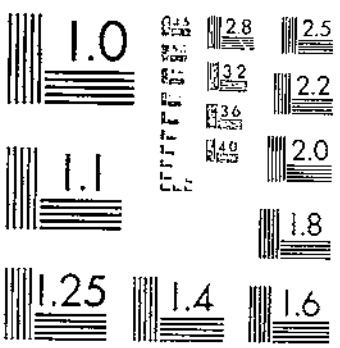

MICROCOPY RESOLUTION TEST CHART
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TECHNICAL BULLETIN NO. 417 MAY 1934

BEEF PRODUCTION AND QUALITY AS INFLUENCED BY CROSSING BRAHMAN WITH HEREFORD AND SHORTHORN CATTLE

By

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UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D.C.

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STATEMENT OF COOPERATION

The research work reported in this bulletin was conducted during the period 1924–27, by the United States Department of Agriculture, the Texas Agricultural Experiment Station, and the King Ranch, Kingsville, Tex.

During the first year, 1924–25, the work was conducted as an independent project. In the second year, 1925–26, the studies were associated with the cooperative project, a study of the factors which influence the quality and palatability of meat, in which the United States Department of Agriculture and a large number of the State agricultural experiment stations are engaged.

The following list of representatives of the cooperating agencies indicates the division of responsibility and coordination of activities:

Administration.—For the United States Department of Agriculture, E. W. Sheets and O. G. Hankins, Bureau of Animal Industry; for the Texas Agricultural Experiment Station, A. B. Conner.

Production.—W. H. Black, A. T. Semple, E. W. McComas, and Bradford Knapp, Jr., Bureau of Animal Industry; J. L. Lush,[1] Texas Agricultural Experiment Station; R. J. Kleberg, Sr.,[2] R. J. Kleberg, Jr., R. M. Kleberg, Caesar Kleberg, and L. F. Cavazos, King Ranch, Kingsville, Tex.

Cattle and beef-carcass grading.—L. B. Burk and D. J. Slater, Bureau of Agricultural Economics; A. T. Edinger, Bureaus of Agricultural Economics and Animal Industry; O. G. Hankins and A. T. Semple, Bureau of Animal Industry; G. W. Barnes, Texas Agricultural Extension Service; F. G. King and W. J. Loeffel, for stations cooperating on the national project.[3]

Weights of parts and organs and other laboratory studies.—J. L. Lush, Texas Agricultural Experiment Station; W. H. Black, A. T. Semple, K. F. Warner, P. E. Howe, N. R. Ellis, and F. C. Hilberg,[4] Bureau of Animal Industry; Armour & Co. and Swift & Co.

Cooking tests and palatability calculations.—Lucy M. Alexander, Bureaus of Home Economics and Animal Industry; C. Rowena Schmidt, Bureau of Home Economics.

Palatability grading.—Louise Stanley and C. Rowena Schmidt, Bureau of Home Economics; Sybil Smith, Office of Experiment Stations; L. B. Burk, Bureau of Agricultural Economics; W. H. Black, P. E. Howe, and D. A. Spencer, Bureau of Animal Industry; A. T. Edinger, Bureaus of Agricultural Economics and Animal Industry.

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[1] Resigned December 1929.
[2] Deceased.
[3] Services made available by the Purdue University (Ind.) Agricultural Experiment Station and the Nebraska Agricultural Experiment Station, respectively, together with the National Livestock and Meat Board and the Bureau of Animal Industry.
[4] Resigned July 1930.

TECHNICAL BULLETIN No. 417 MAY 1934

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By W. H. BLACK, *senior animal husbandman*, and A. T. SEMPLE, *associate animal husbandman, Animal Husbandry Division, Bureau of Animal Industry, United States Department of Agriculture*, and J. L. LUSH, *animal husbandman, Texas Agricultural Experiment Station*

(The Bureaus of Animal Industry, Agricultural Economics, and Home Economics in cooperation with the Texas Agricultural Experiment Station)

CONTENTS

BRAHMAN CATTLE IN UNITED STATES

A few Brahman (Zebu) cattle, the humped cattle native to India, were introduced into South Carolina in 1849 and other small importations were made the next decade or shortly afterward. Some of these cattle reached Texas soon after the Civil War. However, Brahman cattle did not receive much public notice until 1906, when the large Pierce-O'Connor importation was made by A. P. Borden. Parr (*9, p. 13*)[1] and Mohler (*8*) give detailed information concerning this importation. Brahman cattle have been crossed extensively with the cattle of the coastal plains of Texas, with the object of producing larger, hardier, and more prolific cattle which would become fatter than the native cattle under the same conditions (*10, p. 16*). In the early years practically all crosses were made on herds of non-

[1] Italic numbers in parentheses refer to Literature Cited, p. 53.

descript cattle. However, during recent years a number of cattlemen in this region have built up grade Hereford, Shorthorn, and Aberdeen-Angus herds, on which they have sometimes used Brahman bulls or have bred Hereford, Shorthorn, Aberdeen-Angus, or Red Polled bulls to grade Brahman cows. Cattle having Brahman blood are found in considerable numbers along the Gulf coast from the Mexican border to southern Florida and are especially numerous from the region about Corpus Christi, Tex., to western Louisiana. A few Brahmans have been introduced into the southern parts of California, Arizona, and New Mexico and into western Texas and other sections of the range area.

Practically no attempt has been made to breed pure Brahmans for beef production. Instead, they have been used for crossbreeding, the most popular plan being to produce market cattle having from one fourth to one half Brahman blood. Most of these so-called Brahman cattle are sold to the packers by the ranchmen either direct or on the central markets. Large numbers of those that do not go direct from the ranch to the packing plant are shipped to Oklahoma or Kansas pastures and are grazed there through a spring and summer season. They are then sold on the central markets, and nearly all are bought by the packers. Very few Brahman cattle, even those containing only a little Brahman blood, are ever fed heavy grain rations in feed lots.

Though of nervous disposition, Brahman cattle quickly learn to know their feeder and become gentle if he is patient and quiet. Strangers and unusual disturbances tend to excite these cattle. Because of lack of experience with these cattle on the part of practical feeders and the possibility that these animals may furnish an important supply of raw material for the Nation's feed lots, it was thought desirable to determine experimentally how they compare in the feed lot with the better known beef breeds.

PLAN OF EXPERIMENTS

Besides the usual feed-lot data, such as weights and gains, feed consumption, and selling prices, it was considered desirable to find out what differences, if any, existed between cattle of Brahman and non-Brahman breeding with respect to feeder and slaughter cattle grades and carcass grades, the various organs and parts, the proportions of the various cuts of meat, and the color, palatability, quality, and general desirability of the meat for market.

Opportunity to carry out such an experimental study was afforded by a cooperative agreement between the United States Department of Agriculture, the Texas Agricultural Experiment Station, and the King Ranch, Kingsville, Tex., by which the ranch supplied the cattle, feed, and equipment, and received the proceeds from the sale of the cattle; the Animal Husbandry Division of the Department of Agriculture furnished representatives to feed, weigh, and care for the cattle, keep the records, and report the progress of the experimental feeding; and the Texas station, assisted by the Animal Husbandry Division, collected and interpreted the slaughter data.

In addition, the second and third years' work were made a part of the cooperative project on factors which influence the quality and palatability of meat.

Approximately 100 steer calves and yearlings were fed each of three winters. Table 1 presents analyses of the feeds given. The steers were divided into four lots, care being taken to have them as nearly equal in every respect, except breeding, as the cattle available permitted. The live animals were graded at the market just before slaughter and the carcasses graded after being chilled. The pens in which the cattle were fed were approximately 72 by 86 feet. Each lot had a space of approximately 18 by 36 feet under an open shed on the north side of the lots. Descriptions of the cattle used are given in the reports of each year's work.

TABLE 1.—*Average analyses of principal feeds used during the 3 experiments*[1]

Feed	Period of feeding	Analyses	Moisture	Ash	Crude protein	Crude fiber	Nitrogen-free extract	Ether extract
		Number	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Kafir and darso heads, ground	1924–25	2	9.6	3.4	11.1	7.8	65.7	2.4
Hegari heads, ground	1925–26	1	15.9	4.0	8.5	6.0	64.1	1.5
Do	1926–27	2	9.0	4.5	10.9	14.6	58.4	2.6
Threshed hegari, ground	1926–27	3	12.6	1.6	11.9	2.4	70.1	1.4
Shelled corn, ground	1924–25	9	10.4	1.3	10.0	2.3	71.9	4.1
Do	1925–26	2	14.2	1.2	9.4	2.0	71.1	2.1
Do	1926–27	3	10.0	1.5	10.6	2.7	70.8	4.4
Ear corn with husk, ground	1925–26	2	10.5	1.8	8.5	9.8	68.1	3.3
Cottonseed cake	1924–25	3	8.2	5.7	43.0	11.1	25.4	6.6
Do	1925–26	5	8.3	6.8	41.9	10.7	29.8	6.5
Do	1926–27	4	6.6	5.8	43.6	11.4	26.0	6.6
Silage (mostly red-top sorgo, some containing a little corn)	1924–25	6	73.2	3.1	1.9	7.3	13.8	.7
Rhodes-grass hay	1924–25	3	9.4	7.6	4.8	34.2	43.2	.9
Do	1925–26	5	8.1	9.2	6.0	33.5	41.3	1.3
Rhodes-grass hay (chopped)	1926–27	5	8.2	8.3	4.8	32.5	44.0	1.3
Hegari stover, chopped	1926–27	6	12.0	10.0	6.1	28.8	41.4	1.7

[1] All analyses were made under the direction of G. S. Fraps, chief of the division of chemistry, Texas Agricultural Experiment Station.

FEED-LOT AND MARKETING DATA

THE 1924–25 EXPERIMENT

CATTLE USED

During the first year a direct comparison was obtained between Hereford and Brahman-Hereford steers and between Shorthorn and Brahman-Shorthorn steers. The Herefords and Brahman-Herefords were raised in the same or nearby pastures and were from the same herd of Hereford cows, some of which were purebred and the remainder very high grade (figs. 1 and 2). The Shorthorn and Brahman-Shorthorn steers were raised in the same pastures or near each other but on portions of the ranch apart from the Herefords and the Brahman-Herefords. The dams of these steers were purebred or very high-grade Shorthorns. The Brahman bulls which sired all the cross-bred calves were high grades, carrying from about three fourths to seven eighths Brahman blood.

Five head of average calves from each of the four lots were shipped to Fort Worth, Tex., on October 28, 1924, shortly before the beginning of the experiment. There they were sold and slaughtered to determine what differences existed among the lots when they went on feed. The calves were in rather thin condition (figs. 3 and 4).

The 100 steer calves and yearlings that were selected at the same time as the 20 calves which were slaughtered were kept in a dry

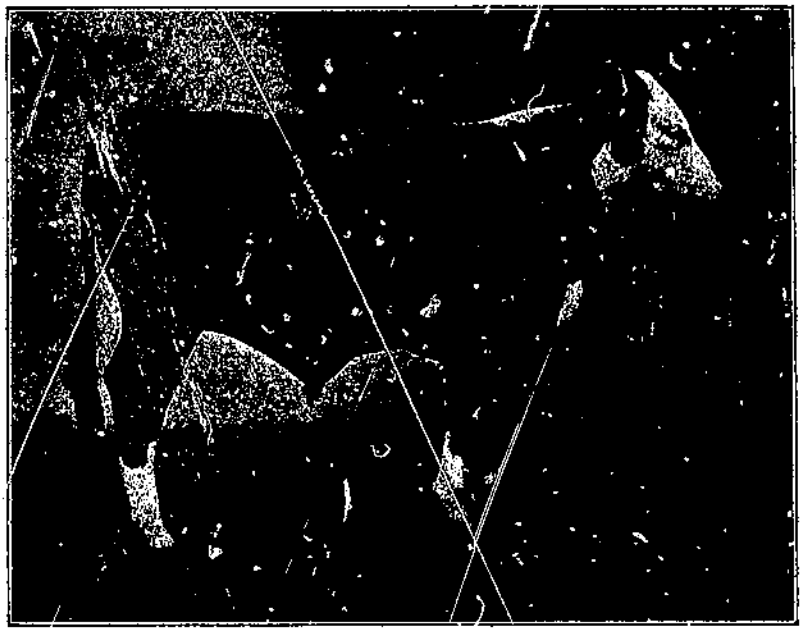

FIGURE 1.—One of the best steers of the Brahman-Hereford group, at the end of the 1924–25 experiment.

FIGURE 2.—Brahman-Hereford group at the end of the 1924–25 experiment.

lot on a preliminary feed for nearly 4 weeks before the beginning of the feeding experiment. They had been dipped on October 23 and were free of ticks. One Brahman-Hereford steer had to be removed from the experiment during the fourth period on account of sickness caused, as the autopsy showed, by a short piece of baling wire evi-

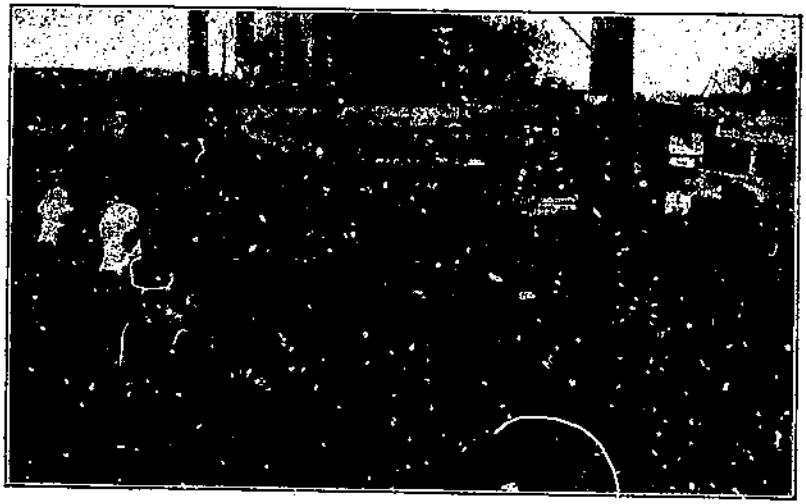

FIGURE 3.—Brahman-Hereford calves selected for slaughter off grass in October shortly before the beginning of the 1924–25 experiment.

FIGURE 4.—Brahman-Shorthorn calves selected for slaughter off grass in October shortly before the beginning of the 1924–25 experiment.

dently swallowed by the animal. No other serious disturbance of health was observed.

During this experiment as well as the two following ones, the non-Brahmans tended to clean up their feed in a very short time after it was placed before them. The steers of Brahman breeding, on the other hand, ate at intervals throughout the day. This same difference

in feeding habits has been observed in other experiments. The quantity of feed given was regulated according to the thoroughness with which the steers cleaned up their feed bunks before the next feeding time and by the apparent eagerness of the steers for feed when feeding time approached.

The weather for the 6 months of the experiment was unusually dry. Heavy frost occurred or a little ice formed in the watering troughs a few times during the winter, but the afternoon temperatures, taken between noon and 3 p.m., averaged 75° F. for February and 77° for March. Late in April and in May it became warm enough for the heat to affect noticeably the appearance and behavior of the cattle.

About a third of the steers from each lot were shipped to Fort Worth and slaughtered after only 4 months of feeding. The rest were continued on feed 2 months longer. This was done to find whether there were differences in their performance during short feeding periods not parallel to the differences found after long feeding periods.

FEEDS USED

The ration for each lot consisted of limited quantities of cottonseed cake and a full feed of ground grain and Rhodes-grass hay. Silage was fed during the first four of six 30-day periods. Several changes in the ration were made during the experiment as it was necessary to use such home-grown feeds as were available. The same changes were made in all lots. From the beginning of the experimental feeding, November 24, 1924, until February 22, 1925, a period of 90 days, the grain consisted of a mixture of darso and white kafir heads ground fine enough to crack all the grains. During the next 12 days a gradual change was made to the feeding of ground ear corn, husks included. As the supply of this feed became low, ground shelled corn was fed, the change being made gradually from March 14 to March 23.

The cottonseed cake used first was of the size known commercially as walnut size. Later, screenings from the production of the regular walnut-sized cake were used. The average of three analyses during the experiment was 43 percent of crude protein. The silage was made mostly from red-top sorgo, the remainder being corn silage and some mixed corn-and-sorgo silage.

The Rhodes-grass hay, which had been baled, was of good quality except that a few bales were too ripe. From time to time the material left in the bottom of the hay racks was cleaned out, weighed, and deducted from the quantities of hay fed, to obtain the quantities consumed.

RATIONS AND DAILY GAINS

The grain ration was increased from about 6 or 7 pounds during the first 30 days to 15 or 16 pounds the fourth 30 days. The cottonseed-cake ration was a trifle more than 1 pound for the first 30 days and about 3.5 pounds during the fourth 30 days. Silage was fed at the rate of about 9 pounds a head daily during the first period and about 5 pounds during the second, third, and fourth periods. The hay ration was decreased from an average of more than 4 pounds during the first period to an average of 2 pounds the fourth period. During the fifth and sixth periods the rations remained practically constant.

The weights of the steers by periods are shown graphically in figure 5. Summaries of the results of the first 120 days' and last 59 days' feeding for the 1924–25 experiment are shown in table 2.

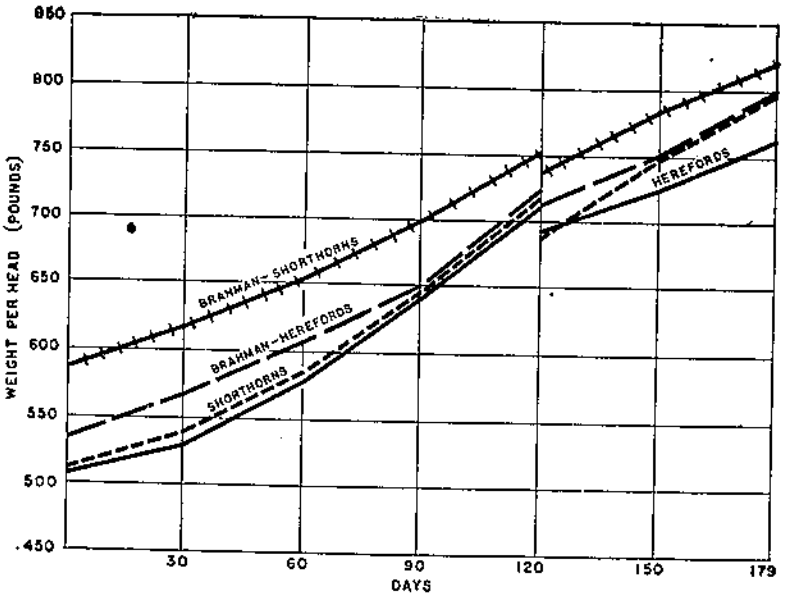

FIGURE 5.—Average live weights of the different lots during the first experiment, 1924–25.

TABLE 2.—*Average initial and final weights, daily gains, rations, and feed required per 100 pounds' gain*

FIRST 120 DAYS, NOV. 24, 1924–MAR. 24, 1925

Breeding	Steers	Initial weight	Final weight	Daily gain	Daily feed per steer				Feed per 100 pounds' gain			
					Grain, ground	Cotton-seed cake	Silage	Hay	Grain, ground	Cotton-seed cake	Silage	Hay
	Number	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
Hereford	25	500	711	1.69	10.42	2.39	5.93	2.79	618	141	351	165
Shorthorn	25	513	714	1.68	10.90	2.51	5.93	3.37	648	149	353	201
Brahman-Hereford	24	536	724	1.57	11.20	2.55	5.98	3.09	713	162	381	196
Brahman-Shorthorn	25	588	753	1.38	12.17	2.70	5.03	4.20	883	203	431	312
LAST 59 DAYS, MAR. 24, 1925–MAY 22, 1925												
Hereford	17	694	762	1.17	11.99	2.37	0	1.98	1,028	203	0	170
Shorthorn	17	687	799	1.89	14.93	2.94	0	2.85	788	156	0	150
Brahman-Hereford	16	712	800	1.50	13.53	2.67	0	2.63	904	179	0	176
Brahman-Shorthorn	17	735	820	1.45	15.14	2.97	0	3.33	1,047	205	0	230

MARKETING DATA

Table 3 shows the average amount and percentage of shrinkage per head between the final weights of the cattle on the ranch (6 miles from the shipping pens) and their sale weights in the stockyards at Fort Worth.

TABLE 3.—*Average shrinkage per head between feed lot and market,*[1] *1924–25*

Breeding	Steers at beginning of experiment (average of 5 head) [2]		Steers fed 120 days (average of 8 head)		Steers fed 170 days (average of 16 or 17 head)	
	Pounds	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*
Hereford	15.0	3.3	47.2	8.8	36.5	4.8
Shorthorn	10.0	2.0	47.2	7.4	29.3	3.6
Brahman-Hereford	30.0	5.4	52.9	8.0	35.2	4.4
Brahman-Shorthorn	10.0	1.7	49.9	7.6	35.1	4.3

[1] The time between weighing in the King Ranch feed lots and in the Fort Worth stockyards was approximately 72 hours for each shipment.

[2] These are approximate weights; scale available for this determination weighed only to 5-pound units, hence all 5 calves in each lot were weighed together and total weight divided by 5.

Table 4 shows the average dressing percentages based on both final feed-lot and sale weights. Packing companies are interested in a high yield of carcass beef from the live weights of the cattle as purchased. However, sale weights are affected to a large extent by the shrink which occurs in the movement from feed lots to market and by the fill which the animals take between arrival at the market and time of sale. The shrink and fill vary according to the time the animals are in transit, the weather, the condition of the cattle, the feed and water given, and other factors. Consequently, in a study of the capacity of cattle for producing beef, sale weights are not an entirely satisfactory basis for computing dressing percentages. Final feed-lot weights, therefore, also are presented and are considered a more suitable basis for comparing yields of dressed meat from the steers used in these experiments.

TABLE 4.—*Average dressing percentages of experimental cattle, 1924–25*

Breeding	Dressing percentages calculated from—					
	Sale weights and warm-carcass weights, shrunk 2.5 percent [1]			Final feed-lot weights and warm-carcass weights		
	Steers at beginning of experiment (5 head)	Steers fed 120 days (8 head)	Steers fed 170 days (16 or 17 head)	Steers at beginning of experiment (5 head)	Steers fed 120 days (8 head)	Steers fed 170 days (16 or 17 head)
Hereford	55.7	57.8	57.2	55.2	55.4	55.8
Shorthorn	54.3	55.7	56.6	54.0	53.9	55.9
Brahman-Hereford	56.3	59.5	59.4	54.6	56.6	58.3
Brahman-Shorthorn	55.4	59.2	61.4	55.8	56.8	60.2

[1] It is ordinary commercial practice to calculate dressing percentage on sale weights and warm-carcass weights which are shrunk a small percentage, predetermined from the average of a large number of carcasses to allow for the loss of water while the carcass is cooling.

Table 5 shows the average live-weight sale prices and appraised values of the carcasses per 100 pounds.

TABLE 5.—*Comparison of average live-weight sale prices and appraised values of carcasses, per 100 pounds,[1] for the 3 slaughter periods of the 1924–25 experiment*

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Live weight	Carcass	Live weight	Carcass	Live weight	Carcass
Hereford	$4.75	$9.53	$8.25	$15.71	$9.25	$15.11
Shorthorn	4.00	7.77	7.75	13.81	9.25	14.89
Brahman-Hereford	5.00	9.13	9.00	14.07	9.25	14.23
Brahman-Shorthorn	4.75	8.07	8.50	13.50	8.75	13.38

[1] The live-weight prices are the prices actually paid for the live steers. The appraised values of the carcasses are the average of the values given to each carcass by 3 packer salesmen who worked independently, did not know what the cattle had cost alive, and were merely told to place on each carcass the price they thought they could get for it in their territory.

THE 1925–26 EXPERIMENT

CATTLE USED

In the 1925–26 experiment opportunity was provided to use second-generation Brahman-Shorthorn steers. These were the result of mating Brahman-Shorthorn bulls to Brahman-Shorthorn cows, each of which was of approximately the same breeding as the Brahman-Shorthorns of the previous experiment. However, as a result of the parents having been selected individuals from among a much larger number born in their generation, the second-generation steers were considered to be somewhat more desirable as beef animals than the first generation. To obtain experimental evidence on this point as well as to maintain the general purpose of the experiment, a lot of first-generation Brahman-Shorthorn steers also was included together with 1 lot of Shorthorns and 1 of Herefords as formerly. The Shorthorn lot included practically all the Shorthorn steer calves, 19 in number, available from the ranch's purebred herd. The other lots were selected from larger numbers. Most of the calves were born during February, March, and April 1925.

On October 26 and 27 the cattle were graded by the grading committee and put on preliminary feed. Representative calves from each lot were shipped immediately to Fort Worth for slaughter, to determine the killing qualities of the different lots at the time the feeding began.

On account of recent castrating and dehorning, some trouble was experienced with screw worms during the first month in the Shorthorn and first-generation Brahman-Shorthorn lots. On January 9 one of the first-generation Brahman-Shorthorns was taken out because it was in very poor condition and seemed likely to die. One of the Shorthorns died suddenly on February 10 from unknown cause.

FEEDS USED

The feeding of all four lots began with coarsely ground ear corn in the husk, cottonseed cake, and Rhodes-grass hay. The cake was ground about as fine as ground corn so that it could be mixed more evenly with the grain. The hay was overripe and rather unpalatable, as indicated by the relatively small quantity consumed.

From January 5 to 25, ground hegari heads were fed. As they had been gathered during an unusually wet fall and stored in considerable bulk, some of the heads were slightly moldy. Most of these were picked out as the heads were going into the grinder. After all the hegari heads had been fed, ground shelled corn was substituted.

RATIONS AND DAILY GAINS

Throughout this experiment the feeder endeavored to give the cattle all the concentrates they would clean up before the next feeding. By the middle of the first period the Herefords were eating 6 pounds of corn per head, the Shorthorns 5.5 pounds, the first-generation Brahman-Shorthorns 8.8 pounds, and the second-generation calves 7.2 pounds. After they were eating 10 pounds of grain per head, the ratio of grain to cake was kept at 5 to 1 throughout the experiment. In all the lots the consumption of hay dropped off considerably during the latter part of the first period, although hay was available to the steers at all times. Data on rations and gains are given in table 6. The weights of the steers by periods are shown graphically in figure 6.

TABLE 6.—*Average initial and final weights, daily gains, rations, and feed required per 100 pounds' gain*

Breeding	Steers	Initial weight	Final weight	Daily gain	Daily feed per steer			Feed per 100 pounds' gain		
					Grain, ground	Cottonseed cake	Hay	Grain, ground	Cottonseed cake	Hay
	Number	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
FIRST 120 DAYS, NOV. 6, 1925–MAR. 6, 1926										
Hereford	24	437	670	1.94	11.09	2.47	1.76	572	125	90
Shorthorn	19	485	741	2.13	11.97	2.56	2.22	561	120	104
Brahman-Shorthorn:										
First generation	24	584	810	1.88	14.36	2.92	3.06	764	155	163
Second generation	25	547	773	1.88	12.32	2.61	2.45	654	139	130
LAST 30 DAYS, MAR. 6–APR. 5, 1926										
Hereford	17	668	715	1.56	13.17	2.64	1.91	832	167	120
Shorthorn	10	720	777	1.90	15.07	3.03	2.35	794	160	124
Brahman-Shorthorn:										
First generation	10	703	840	1.55	15.64	3.13	3.48	1,007	201	224
Second generation	17	709	802	1.10	13.40	2.63	2.87	1,220	244	261

MARKETING DATA

In the selection of the cattle to be shipped at the end of the fourth 30-day period, representative steers were picked out as far as possible. Tables 7, 8, and 9 present the comparative data on shrinkage, dressing percentages, and prices for the four lots. The very low prices for the first-generation calves in the shipment at the beginning of the experiment were caused by their being staggy and having practically no covering of fat. As shown in table 7, the first two shipments were marketed at Fort Worth, Tex., and the last at Kansas City, Mo. Since the distance to the Kansas City market was about twice that to Fort Worth, there is an opportunity to observe the effect of added time and distance on the shrinkage of the steers in the four lots.

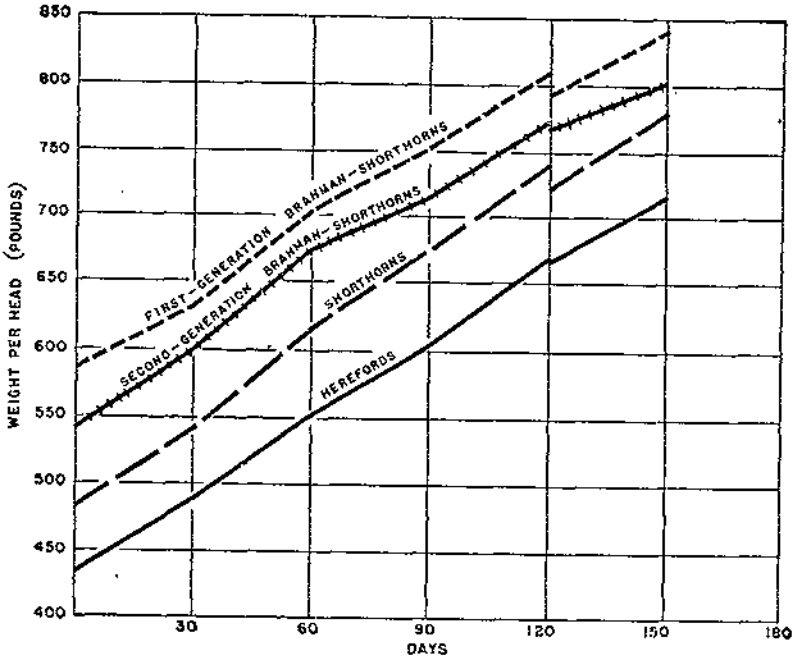

FIGURE 6.—Average live weights of the different lots during the second experiment, 1925–26.

TABLE 7.—*Average shrinkage per head in live weight between feed lot and market, 1925–26* [1]

Breeding	Steers at beginning of experiment (4 or 5 head)		Steers fed 120 days (6 to 9 head)		Steers fed 150 days (10 to 15 head)	
	Pounds	*Percent*	*Pounds*	*Percent*	*Pounds*	*Percent*
Hereford	29.6	7.6	51.7	7.6	50.4	7.0
Shorthorn	49.0	9.2	52.1	6.8	64.9	8.3
Brahman-Shorthorn:						
First generation	36.0	6.2	58.4	6.9	60.0	7.1
Second generation	38.0	6.9	59.1	7.6	60.3	7.4

[1] The first two shipments were marketed at Fort Worth, Tex., and the final shipment at Kansas City, Mo. The time elapsing between ranch feed-lot weighings and sale weighings at Fort Worth was approximately 72 hours. For the Kansas City shipment, the time was approximately 216 hours. The distance by rail from ranch shipping point to Fort Worth is 547 miles and to Kansas City 1,119 miles.

TABLE 8.—*Average dressing percentages of experimental cattle, 1925–26*

Breeding	Dressing percentages calculated from—					
	Sale weights and warm carcass weights, shrunk 2.5 percent [1]			Final feed-lot weights and warm carcass weights		
	Steers at beginning of experiment (4 or 5 head)	Steers fed 120 days (6 to 9 head)	Steers fed 150 days (10 to 15 head)	Steers at beginning of experiment (4 or 5 head)	Steers fed 120 days (6 to 9 head)	Steers fed 150 days (10 to 15 head)
Hereford	53.3	58.5	58.6	50.5	55.4	55.8
Shorthorn	50.5	58.9	60.6	52.3	58.3	56.7
Brahman-Shorthorn:						
First generation	57.0	61.0	60.7	54.8	58.2	57.7
Second generation	57.3	60.6	61.2	54.7	57.5	57.8

[1] See footnote to table 4.

TABLE 9.—*Comparison of average live-weight sale prices and appraised values of carcasses, per 100 pounds,*[1] *for the 3 slaughter periods of the 1926–28 experiment*

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 150 days	
	Live weight	Carcass	Live weight	Carcass	Live weight	Carcass
Hereford	$6.00	$9.93	$9.35	$16.71	$9.00	$13.97
Shorthorn	5.95	10.04	9.60	16.33	8.50	13.45
Brahman-Shorthorn:						
First generation	5.00	7.13	9.15	15.19	8.50	13.29
Second generation	6.82	12.43	8.85	15.81	8.50	13.34

[1] See footnote to table 5.

THE 1926–27 EXPERIMENT

CATTLE USED

The third test, which began October 6, 1926, included a supplementary feeding test as well as continuing the main purpose of the experiment. It was thought that the somewhat unsatisfactory gains of the first 2 years might have been due to the Rhodes-grass hay, a feed which has been used very little in experimental feeding. Results obtained previously from the feeding of this hay are reported by Fraps (*4*) and Tracy (*12*). Consequently, half of the steers were fed Rhodes-grass hay as a roughage and the remainder received hegari stover. The use of both these roughages also broadened the scope of the experiment somewhat by showing how the lots responded to the different feeds.

The cattle used were 98 yearling steers, of medium to good grade, which had been put on Rhodes-grass pasture and cottonseed cake to fatten. Of these steers, 25 were Herefords, 24 were Shorthorns, and 49 were Brahman-Shorthorns. Since the data already obtained on the comparative merits of first and second generation Brahman-Shorthorns were considered adequate, these groups were combined in the present phase of the experiment. The market and slaughter data obtained in the preceding 2 years from those feeder steers killed at the beginning of the experiment were deemed ample, and this line of study was therefore not continued.

FEEDS USED

In order to continue the comparison of part-Brahman and non-Brahman cattle and at the same time conduct the roughage test, one lot of Herefords and Shorthorns and one lot of Brahman-Shorthorns were fed chopped Rhodes-grass hay, whereas another lot of Herefords and Shorthorns and another lot of Brahman-Shorthorns were fed chopped hegari stover. They were put on full feed gradually. When the supply of hegari grain was almost exhausted, ground shelled corn was gradually substituted. Cottonseed cake was fed to all lots.

The Rhodes-grass hay and hegari stover, which were chopped in a silage cutter, were fed very liberally to make certain that the cattle had all these roughages they could eat. During the last three periods some reduction was made in the roughage in order to increase the consumption of concentrates and hasten fattening.

RATIONS AND DAILY GAINS

The part-Brahman lots consumed more grain and less roughage per steer and per 100 pounds of gain, on the average, throughout the feeding tests, than did the non-Brahmans. The part-Brahman steers reached their maximum grain consumption of approximately 15 pounds per head per day during the fourth 28-day period, whereas the non-Brahmans reached their maximum of 14 pounds per head daily during the fifth period. Roughage consumption was greatest with the part-Brahmans during the second period and with the non-Brahmans during the third period. Both the part-Brahmans and the non-Brahmans consumed more hegari stover than Rhodes-grass hay. During the period that each of the roughages was fed, the part-Brahman cattle consumed 9.40 pounds of hegari stover and 7.07

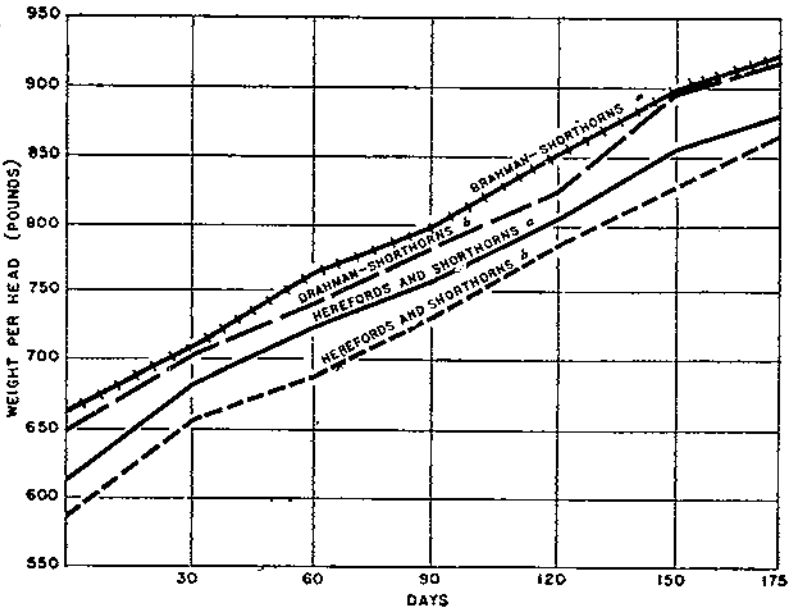

FIGURE 7.—Average live weights of the different lots during the third experiment, 1926–27: *a*, Fed Rhodes-grass hay; *b*, fed hegari stover.

pounds of Rhodes-grass hay per head daily, as compared with 10.64 pounds of stover and 8.79 pounds of hay consumed by the non-Brahmans.

During the first period the non-Brahmans made good gains, but during the rest of the experiment their gains were not satisfactory when compared with the quantities of feed consumed. The same was true of the part-Brahman lots, except for one period when the lot fed hegari stover gained more than 2 pounds per steer daily.

A summary of the daily gains, daily rations, and feed required per 100 pounds of gain is given in table 10. The weights of the steers by periods are shown graphically in figure 7.

TABLE 10.—*Average initial and final weights, daily gains, rations, and feed required per 100 pounds' gain during the entire feeding time of 175 days, Oct. 6, 1926–Mar. 30, 1927*

Breeding and number of cattle and feed used	Initial weight	Final weight	Daily gain	Daily feed per steer			Feed per 100 pounds, gain		
				Grain, ground	Cottonseed cake	Roughage	Grain, ground	Cottonseed cake	Roughage
Non-Brahman lots:	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
13 Hereford, 11 Shorthorn (fed Rhodes-grass hay)	614	880	1.52	11.13	2.87	8.70	732	189	573
12 Hereford, 13 Shorthorn (fed hegari stover)	588	863	1.57	10.30	2.78	10.64	656	177	678
Part-Brahman lots:									
24 Brahman-Shorthorn (fed Rhodes-grass hay)	662	922	1.49	12.72	2.90	7.07	856	195	476
25 Brahman-Shorthorn (fed hegari stover)	650	918	1.53	12.44	2.94	9.40	812	192	614

MARKETING DATA

After individual final weights were taken for 3 consecutive days, the cattle were shipped to Fort Worth, Tex. They were in transit about 44 hours, were sold the next day, and were slaughtered within the next 2 days.

Table 11 gives the average shrinkage in transit, the actual sale prices per 100 pounds live weight, the dressing percentages based on ranch and sale weights, and the appraised carcass values.

TABLE 11.—*Average shrinkage in transit, sale prices, dressing percentages, and appraised carcass values of experimental cattle, 1926–27*

Breeding and number of cattle and feed used	Shrinkage in transit		Sale price per 100 pounds' live weight	Appraised carcass values per 100 pound weight	Dressing percentages calculated on—	
					Sale weight and warm carcass weight shrunk 2.5 per cent [1]	Final feed-lot weights and warm carcass weights [2]
Non-Brahman lots:	*Lb.*	*Percent*	*Dollars*	*Dollars*	*Percent*	*Percent*
13 Hereford, 11 Shorthorn (fed Rhodes-grass hay)	48	5.46	9.00	14.53	58.1	56.3
12 Hereford, 13 Shorthorn (fed hegari stover)	46	4.29	8.50	14.49	55.9	54.9
Part-Brahman lots:						
24 Brahman-Shorthorn (fed Rhodes-grass hay)	41	5.02	9.00	14.64	60.1	58.5
25 Brahman-Shorthorn (fed hegari stover)	37	4.44	9.00	14.82	60.0	58.8

[1] See footnote to table 4.
[2] See footnote to table 5.

DISCUSSION OF DATA

Table 12 summarizes the average performance of the Hereford and Shorthorn steers as contrasted with those containing Brahman blood. The preceding tables provide an opportunity for more specific comparisons of the various groups for the 3 years.

In daily gain, as shown in tables 2, 6, and 10, the non-Brahman lots excelled, though the degree of difference varied considerably, especially late in the fattening periods. For instance, in the last 30 days of the second year the non-Brahmans excelled the part-Brahmans in average daily gains by about 24 percent; whereas during the following year, for the entire feeding period, the corresponding difference was less than 3 percent. On the whole the daily gains of the Herefords and Shorthorns were moderately greater than those of the Brahman crossbreds.

TABLE 12.—*Differences between experimental lots of non-Brahman and part-Brahman steers with respect to various factors in beef production (average of all experiments)*[1]

Breeding	Daily gain	Economical use of feed		Low shrinkage, feed lot to market	Sale price per 100 pounds live weight	Dressing percentage	Appraised value of carcass per 100 pounds
		Concentrates	Roughage				
Hereford and Shorthorn	++	++	+	----------	----------	----------	++
Brahman-Hereford and Brahman-Shorthorn	----------	----------	----------	+	+	+++	----------

[1] +=slight superiority; ++=moderate superiority; +++=superiority highly significant statistically (P is less than 0.01).

In connection with these data, the nervous disposition of the Brahman crossbreds probably was responsible in part for their making smaller gains than did the non-Brahmans. The handling incident to the monthly weighings was observed to excite them much more than the other breeds.

In quantity of feed per 100 pounds of gain, as shown in tables 2, 6, and 10, the non-Brahmans consumed, with a few exceptions, considerably less grain and cottonseed cake and slightly less hay than the part-Brahmans. However, when this is expressed as total feed consumed per 100 pounds of live weight, there is practically no difference. The part-Brahmans ate their feed a little at a time but came back to the feed troughs and hay racks many times during the day for more, whereas the non-Brahmans usually consumed their feed in a comparatively short period.

In percentage of shrinkage in live weight between feed lot and market (tables 3, 7, and 11) the non-Brahman lots shrank less the first year, but in the next 2 years their shrinkage was greater. Differences in most cases were small with the net difference for the 3 years, with respect to low shrinkage, slightly in favor of the part-Brahmans.

Average sale prices per 100 pounds of live weight were greater for the non-Brahman lots during the second year (table 9), but for the first and third years, the difference, though slight, was in favor of the part-Brahmans (tables 5 and 11). On the average the Brahman-Herefords and Brahman-Shorthorns sold for slightly more, per 100 pounds of live weight, than the Herefords and Shorthorns, but the differences were so inconsistent from one marketing to another that the average difference is not significant.

Dressing percentages (tables 4, 8, and 11) of the steers of Brahman breeding were consistently greater than those of the non-Brahmans. The usual difference was between 2 and 4 percent, with an average of 2.4. This difference is significant from a market standpoint because of the greater yield of meat from the same weight of live animal. The differences for the various lots were so consistent that the higher dressing percentage of cattle of Brahman breeding is indisputable.

In appraised values of carcasses per 100 pounds of weight, as shown in tables 5, 9, and 11, the non-Brahman lots were slightly higher than the part-Brahmans for the first 2 years and slightly lower the last year. The small net difference was in favor of the non-Brahmans.

The average appraised values of the non-Brahman carcasses were slightly higher than those of the part-Brahman. In view of the fact that there was essentially no difference between the live-weight sales prices, the higher dressing percentage of the part-Brahmans offset their slightly lower carcass value per pound.

The comparison of first- and second-generation Brahman-Shorthorn steers for desirability as beef animals showed no consistent advantage of one group over the other. Although the second-generation steers were the result of more selective breeding, measurable differences for the entire experiment were slight. As seen in table 6, daily gains for the first 120 days were the same, but during the last 30 days the first-generation steers gained considerably more. Table 6 also shows that although the first-generation lot consumed more feed per 100 pounds of gain during the first 120 days, they consumed less during the last 30 days, there being, on the whole, practically no difference in feed consumption between the two lots. Average shrinkage in live weight between feed lot and market, as shown by table 7, was somewhat higher in the case of the second-generation lot. Dressing percentages (table 8) were practically the same for the two lots. Live-weight sale prices and appraised values of carcasses per 100 pounds (table 9) for the second generation were considerably higher at the beginning of the experiment but showed very little difference afterward.

From the standpoint of the producer or rancher raising and marketing steers for beef under the conditions in which these experiments were conducted, table 13 offers some noteworthy comparisons. In the 2 years that sample shipments of steer calves were made direct from grass the part-Brahman steers made gross returns of $26.35 and $31.42 per steer, respectively, as against $20.45 and $24.53 for the non-Brahman steers. Difference in returns of $5.90 and $6.89 are of great significance to the producer selling calves off grass at weaning time. As an average for the 2 years the part-Brahman calves weighed 91 pounds more per head and sold for about $0.28 more per hundredweight, than the non-Brahman calves.

When similar calves were placed in the dry lot and fattened for periods ranging from 120 to 179 days, the differences were not consistently in favor of either group. If the returns, less feed charges, for the first 120 days of feeding in the 1924–25 experiment are averaged with the corresponding results in 1925–26, a difference of $0.84 per head is obtained in favor of the part Brahmans.

TABLE 13.—*Sale weights and prices and gross returns, for steers marketed at various stages of fattening*

Time of marketing	Non-Brahman					Part-Brahman				
	Head	Average sales weight per steer	Average sale price per hundredweight	Average gross return per steer		Head	Average sales weight per steer	Average sale price per hundredweight	Average gross return per steer	
				Total	Less feed charges				Total	Less feed charges
1924–25 experiment:	*Number*	*Lb.*	*Dollars*	*Dollars*	*Dollars*	*Number*	*Lb.*	*Dollars*	*Dollars*	*Dollars*
At beginning of experiment	10	470	4.33	20.45		10	541	4.86	26.35	
After 120 days	16	699	8.60	55.92	24.04	16	708	8.75	61.78	28.85
After 179 days	33	749	9.25	69.28	14.41	33	775	9.00	69.75	10.12
1925–26 experiment:										
At beginning of experiment	9	417	5.88	24.53		10	528	5.95	31.42	
After 120 days	15	678	9.50	64.41	35.74	16	753	9.00	67.77	34.60
After 150 days	27	682	8.81	60.08	21.42	33	760	8.50	64.60	20.94
1926–27 experiment:										
After 175 days	40	824	8.75	72.10	19.61	40	881	9.00	79.29	23.13

After the feeding period of 150 days in 1925–26, however, there was a difference of $0.48 in favor of the non-Brahmans. Moreover, when the results of the 179-day period in 1924–25 are averaged with those of the 175-day period in 1926–27 a difference of $0.40 a head is obtained in favor of the non-Brahmans.

Thus it will be observed that the part-Brahmans show to better advantage than the non-Brahmans when fed for a period not exceeding 120 days when gross sale price less feed charges is used as the basis for comparison.

The experiments indicate that as a rule steers of Brahman breeding will not gain weight so rapidly in feed lots during a long feeding period as Hereford and Shorthorn steers. The difference is small but fairly consistent. Data published by the Texas Agricultural Experiment Station (*5*, *6*, *7*) support the conclusion that cattle of Brahman breeding gain weight less rapidly in feed lots than Herefords. These data also show that the former grow more rapidly on the range and pastures before being sent to the feed lot. In comparisons at the Texas Station, first-generation Brahman-Herefords gained less rapidly in feed lots than Herefords. In most cases they also weighed more than the Herefords when taken from pasture and placed in the feed lot.

The data on dressing percentages, in the present study, indicate that the superiority of Brahman crossbreds in this respect increases as the feeding period becomes longer.

Some of the observed differences in these studies may be the general effect of crossbreeding resulting in so-called hybrid vigor or heterosis. Others are doubtless the result of characteristics peculiar to Brahman cattle. Only such of the latter as were dominant or intermediate in inheritance could be observed under the conditions of these experiments.

WEIGHTS AND SIZES OF VARIOUS ORGANS AND OTHER PARTS OF BODY, 1924–27

Brahman cattle and the beef breeds of European origin are so different in body conformation that it was thought desirable to determine whether there are significant differences in the weight or size of important vital organs and also of the heads, hides, and other parts of the body that have a bearing on the value of the animals and their products. The packing plants which purchased the cattle extended full cooperation in this study even though the large amount of weighing and measuring interrupted their schedules.

Nearly all parts were weighed as soon as the butchers separated them from the carcasses. Hides were laid aside in the hide cellar until the other data had been obtained and then were weighed and measured at the first opportunity. There were a few mishaps, such as tags becoming torn off or numbers becoming illegible; these account for slightly varying numbers of animals represented in some of the data.

At the earlier slaughterings, nearly all parts which could be weighed with fair accuracy were included. The data were studied after each slaughtering to determine whether there were any significant differences among the lots. In later slaughterings, parts which appeared to have no significant difference were omitted unless they were of considerable economic or physiological importance.

The weights of certain parts, such as heads, hides, and hearts, are associated to some extent with body weight. Since the different groups of steers were not usually equal in average live weight, it was obviously desirable to express many of the data as percentages of body weight.

Special considerations apply also to certain parts. For example, the percentage of weight of head to live weight is very distinctly influenced by age, being larger for younger cattle than for older ones. Also certain tissues such as caul fat, ruffle fat, and paunch fat are intimately related to the degree of fatness of the entire steer. Final feed-lot weights rather than sale weights were used to avoid differences in shrinkages and fills, yet of course even the weights used were influenced slightly by the varying quantities of feed in the digestive tract. Computations were carried to the last decimal place considered possibly significant, depending on the character of the scale used and on the exactness of the experimental methods.

WEIGHTS OF HEADS, TONGUES, AND BRAINS

Table 14 gives the number of cattle in each lot from which slaughter data were obtained and a comparison of weights of heads (exclusive of tongues) with the final feed-lot weights of animals. All the subsequent tables of weights of parts are based on the numbers of steers shown in table 14, unless exceptions are noted.

TABLE 14.—*Comparison of average weights of heads (exclusive of tongues) of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of final live-steer weights at feed lot*

1924–25 EXPERIMENT

Breeding	Steers at beginning of experiment				Steers fed 120 days				Steers fed 170 days[1]			
	Animals slaughtered	Final weight of steer	Weight of heads		Animals slaughtered	Final weight of steer	Weight of heads		Animals slaughtered	Final weight of steer	Weight of heads	
			Average	Percentage of final weight of steer			Average	Percentage of final weight of steer			Average	Percentage of final weight of steer
	Number	*Lb.*	*Lb.*		*Number*	*Lb.*	*Lb.*		*Number*	*Lb.*	*Lb.*	
Hereford	5	455	14.7	3.23	8	731	18.5	2.53	17	762	19.0	2.50
Shorthorn	5	510	15.8	3.10	8	762	18.8	2.46	16	803	19.8	2.47
Brahman-Hereford	5	552	15.8	2.87	8	735	18.3	2.49	16	800	19.4	2.42
Brahman-Shorthorn:												
First generation	5	576	17.1	3.00	8	780	18.7	2.40	17	820	19.9	2.42

1925–26 EXPERIMENT

Hereford	5	392	12.0	3.08	6	678	17.1	2.52	15	721	.....	.....
Shorthorn	4	534	15.3	2.87	9	764	18.0	2.36	10	777	.....	.....
Brahman-Shorthorn:												
First generation	5	578	16.2	2.81	8	842	20.6	2.45	14	849	.....	.....
Second generation	5	552	14.9	2.70	8	782	17.8	2.27	15	817	.....	.....

1926–27 EXPERIMENT

Breeding	Steers fed Rhodes-grass hay 175 days				Steers fed hegari stover 175 days			
	Animals slaughtered	Final weight of steer	Weight of heads		Animals slaughtered	Final weight of steer	Weight of heads	
			Average	Percentage of final weight of steer			Average	Percentage of final weight of steer
	Number	*Pounds*	*Pounds*		*Number*	*Pounds*	*Pounds*	
Hereford	24	880	[2] 24.5	2.79	25	863	23.7	2.75
Shorthorn								
Brahman-Shorthorn:								
First generation	24	922	23.5	2.55	25	918	23.2	2.53

[1] The steers were fed 150 days in 1925–26.
[2] Based on 20 heads, 4 not weighed.

The data pertaining to weights of tongues are given in table 15. When tongue weights are expressed as percentages of the final feed-lot weights, the non-Brahmans have the heavier tongues in every comparison.

TABLE 15.—*Comparison of average weight of tongues of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of final live-steer weights at feed lot*

1924-25 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	3.90	0.96	5.45	0.75	5.78	0.76
Shorthorn	3.80	.75	5.41	.71	5.43	.68
Brahman-Hereford	3.60	.65	4.95	.67	5.23	.65
Brahman-Shorthorn: First generation	3.70	.65	4.97	.64	5.42	.66

1925-26 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 150 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	3.45	0.88	5.30	0.78	5.33	0.74
Shorthorn	4.12	.77	5.92	.77	6.10	.66
Brahman-Shorthorn:						
First generation	4.05	.70	5.48	.65	5.39	.64
Second generation	4.05	.73	5.37	.69	5.50	.67

1926-27 EXPERIMENT

Breeding	Steers fed Rhodes-grass hay 175 days		Steers fed hegari stover 175 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*	
Hereford	6.96	0.79	6.51	0.75
Shorthorn				
Brahman-Shorthorn: First generation	6.58	.71	6.65	.72

Brahman cattle differ so markedly from the other beef breeds in alertness, nervous tendencies, and other mental traits, as well as in the shape of the head, that it was thought possible that a significant difference might be found in weight of brain. Accordingly, the brains of the cattle in the first experiment were weighed.

The data in table 16 show the brains of the non-Brahman cattle to be considerably the heavier, but as the heads and also the tongues of the non-Brahmans were likewise heavier, the differences in weight of brains are not considered significant. As the results were of slight commercial importance, the weighing of brains was discontinued after the first year.

TABLE 16.—*Comparison of the average weights of brains of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of the final live-steer weights at feed lot, 1924–25 experiment*

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	0.704	0.175	0.914	0.125	0.831	0.109
Shorthorn	.791	.155	.715	.091	[1].842	.105
Brahman-Hereford	.800	.145	.084	.093	.812	.101
Brahman-Shorthorn	.850	.140	.727	.093	.805	.098

[1] 1 brain was lost. The data for this lot are based on 15 brains.

SIZE, WEIGHT, AND THICKNESS OF HIDES

One of the conspicuous characteristics of Brahman cattle is the large quantity of loose skin (dewlap) hanging along the midventral line beginning almost at the muzzle and extending to some distance back of the umbilicus. Because of these large dewlaps and because the Brahmans differed so greatly from Hereford and Shorthorn steers in body conformation, it was thought that the Brahmans might be characterized by relatively larger surface areas than the other steers. Accordingly, the area of each hide was measured shortly after the steers were killed. For measuring these areas a large planimeter similar in principle to those used by draftsmen and cartographers was constructed.[2] This planimeter had wooden arms, each 1.23 meters long and a composition fiber wheel 15.3 centimeters in diameter (fig. 8). The arms proved to be slightly too short for convenience in measuring the very largest hides. Otherwise this planimeter was very satisfactory for the work. It was provided with a revolution counter, and the wheel was graduated to hundredths of a revolution. In operation, the end of the arm bearing the wheel was used to trace the irregular outline of the edge of the hide, while the end of the other arm was held at a point on the floor near the edge of the hide. The revolution counter attached to the wheel shows the area directly, in units determined by the proportions of the instrument, when the moving arm completes its circuit and returns to its starting point. Such units were later converted into square feet. The mathematical principles involved are those of the integral calculus of polar coordinates.

This planimeter was calibrated by measuring with it an area of known size on a floor. When this was measured with the planimeter 11 successive times, a standard deviation of 0.156 square foot was found. That is a probable error for a single measurement of slightly more than one tenth of a square foot. Such ideal conditions were not encountered in measuring the hides. There was opportunity for error as the wheel went up on or came down off the hide, and there was also opportunity for a slight error at times when the hide slipped a little with the wheel.

[2] By E. E. Vezoy, Physics Department, Agricultural and Mechanical College of Texas.

In order to estimate the size of the errors actually encountered in measuring the hides, one hide was measured 11 times. The probable error was found to be slightly more than nine tenths of a square foot. On the basis of these findings it was decided to take two measurements of each hide and, if they did not differ by so much as 1 square foot, to use the average of the two as the correct measurement. If, however, the first two measurements differed more than that, additional measurements were made. If the additional measurements showed that one of the first two was very distinctly aberrant it was discarded. If the additional measurements did not show clearly which of the original measurements was aberrant, the average of all measurements made on that hide was used as the correct measurement.

On account of these circumstances the hide areas given are based on averages of from 2 to 5 measurements, and in the authors' judgment

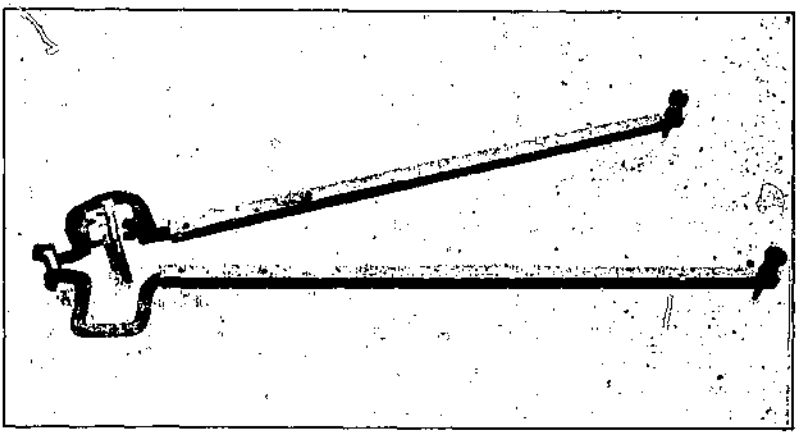

FIGURE 8.—Planimeter used in measuring hide areas.

the probable error of measurement in these averages is less than two thirds of a square foot for each hide. In nearly all groups the variation between steers within the groups far exceeded the error of measurement, and therefore the latter is a very minor element in the difference between group averages. Measurement with the planimeter proved to be very rapid and two men, with a third to make the record, could measure as many as 60 hides in half a day.

The data on hide areas are presented in table 17. In order to eliminate differences which were the direct result of differences in general body size the areas were divided by the two-thirds power of the live weights because in objects geometrically similar in shape the surface varies as the two-thirds power of the volume. Recorded observations (*2, 3, 13*) on the weight per unit volume of cattle indicate that this relationship is approximately constant for steers of similar fatness.

TABLE 17.—*Comparison of the average area of hides of the non-Brahman and part-Brahman lots, expressed in square feet and in relation [1] to final live-steer weights at feed lot*

1924–25 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average size	Relation to final weight of steer	Average size	Relation to final weight of steer	Average size	Relation to final weight of steer
	Sq. ft.		*Sq. ft.*		*Sq. ft.*	
Hereford	33.5	0.57	43.3	0.53	[2] 40.5	0.48
Shorthorn	37.4	.59	41.0	.49	44.5	.51
Brahman-Hereford	37.5	.56	43.6	.53	51.0	.59
Brahman-Shorthorn: First generation	41.2	.60	43.1	.51	49.6	.57

1925–26 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 150 days	
	Average size	Relation to final weight of steer	Average size	Relation to final weight of steer	Average size	Relation to final weight of steer
	Sq. ft.		*Sq. ft.*		*Sq. ft.*	
Hereford	[3] 28.8	0.57	32.0	0.41	39.6	0.49
Shorthorn	34.1	.52	32.9	.39	39.8	.47
Brahman-Shorthorn:						
First generation	40.8	.59	43.0	.48	46.9	.52
Second generation	38.0	.56	37.0	.44	46.0	.53

[1] Figures in this table were obtained by dividing the area of the hides, in square feet, by the two-thirds power of the live weight, in pounds; see text for explanation.
[2] Average of 11 hides.
[3] Average of 4 hides.

The data relating to hide weights are given in table 18 and are expressed both in actual pounds and in percentages of final live-steer weights at feed lot.

The thickness of the uncured hides, including the hair, was studied during the second and third slaughterings of the 1924–25 experiment and the first slaughtering of the 1925–26 experiment. A small machinist's caliper with vernier scale, reading to tenths of a millimeter, was used. At first it was used in the condition in which it was purchased, but the measurements thus taken were erratic owing to the small surfaces of the caliper which came in contact with the hide. To remedy this, copper rivets were soldered to the contact surfaces of the caliper in a manner that did not affect the scale and that made the area of each contact surface about four fifths of a square centimeter. This modified caliper was used on the last 2 of the 3 occasions.

TABLE 18.—*Comparison of average weights of hides of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of final live-steer weights at feed lot*

1924-25 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	39.2	8.6	59.0	8.2	[1] 64.2	8.3
Shorthorn	41.0	8.0	61.7	6.8	64.5	6.8
Brahman-Hereford	50.5	9.2	61.2	8.3	63.8	8.0
Brahman-Shorthorn: First generation	52.0	9.1	58.6	7.5	59.3	7.2

1925-26 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 160 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	[2] 32.8	9.0	53.2	7.8	58.7	8.1
Shorthorn	40.9	7.7	51.4	6.7	53.8	6.9
Brahman-Shorthorn:						
First generation	51.0	9.3	62.9	7.5	64.2	7.6
Second generation	40.7	8.5	56.5	7.2	64.1	7.8

1926-27 EXPERIMENT

Breeding	Steers fed Rhodes-grass hay 175 days		Steers fed hegari stover 175 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*	
Hereford	65.1	7.4	62.2	7.2
Shorthorn				
Brahman-Shorthorn: First generation	65.3	7.1	66.1	7.2

[1] Average of 11 hides.
[2] Average of 4 hides.

The hide was folded flesh side out and the caliper was applied a short distance from the fold. The reading, therefore, was of a double thickness of hide, hair included, and was divided by 2 in obtaining the thickness. The area selected for measurement was on the side approximately midway from back to floor of the chest and about over the fifth to eighth ribs. Special care was used to avoid getting down into the region of the fore flank where the hide was noticeably thinner, or higher on the back where it was noticeably thicker, and to avoid spots where any bits of muscle still adhered to the hide.

Even with the improved caliper the measurements of hide thickness continued to be erratic, being difficult to duplicate and varying from place to place on the same hide.

Since no definite indication of a breed difference in this characteristic was found in the data taken, this feature of the investigation was discontinued. The measurements of hide thickness are not included in this publication.

WEIGHT OF TAILS

The tails were removed from the carcasses on the killing floor. The tails on the part-Brahman steers were noticeably longer and heavier than those of the non-Brahmans. This larger size also was evident when the weights were divided by the corresponding live weights. However, owing to the small importance of tails in an economic sense and probably also physiologically, the data obtained the first year were deemed to be ample and their further study was discontinued. The data are shown in table 19.

TABLE 19.—*Comparison of the average weights of tails of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of the final live-steer weights at feed lot, 1924–25 experiment*

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	0.50	0.11	0.76	0.10	0.94	0.12
Shorthorn	.65	.13	.74	.10	.85	.11
Brahman-Hereford	.85	.15	.83	.11	1.05	.13
Brahman-Shorthorn	.80	.14	.86	.11	.99	.12

WEIGHT OF LEG BONES AND FEET

Early in the skinning process, the hide was removed from the legs. The leg bones were then unjointed at the knee and hock joints and were separated from the carcass. The bones thus removed still had the hoofs attached, although the dewclaws were removed before the hide was skinned off. Practically no muscle tissue w sa present, but there were tendons and other connective tissue and small quantities of other tissues such as blood vessels and nerves. The leg bones were weighed just as they were taken from the steers and the results for the various lots of steers appear in table 20.

TABLE 20.—*Comparison of the average weights of leg bones, including feet, of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of the final live-steer weights at feed lot*

1924–25 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	8.90	1.90	12.03	1.65	12.91	1.69
Shorthorn	10.20	2.00	12.59	1.65	13.19	1.64
Brahman-Hereford	10.00	1.81	12.16	1.65	13.42	1.68
Brahman-Shorthorn: First generation	11.15	1.90	12.78	1.64	13.94	1.70

1925–26 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 160 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	8.20	2.09	10.08	1.57	11.67	1.62
Shorthorn	10.44	1.96	13.11	1.72	12.00	1.54
Brahman-Shorthorn:						
First generation	11.70	2.02	13.10	1.56	13.46	1.59
Second generation	11.25	2.04	12.89	1.65	13.44	1.64

1926–27 EXPERIMENT

Breeding	Steers fed Rhodes-grass hay		Steers fed hegari stover	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*	
Hereford, Shorthorn	14.96	1.70	14.03	1.63
Brahman-Shorthorn: First generation	15.11	1.64	[1] 15.10	1.65

[1] All legs of 5 steers and 1 leg of another in this group of 24 steers not weighed.

WEIGHTS OF HEARTS AND LUNGS

The hearts were weighed just as they were removed from the pluck. They had been cut open and all blood was removed. Data pertaining to the weights of the hearts are shown in table 21.

The lungs, including the tracheae, were weighed immediately after they were taken from the steers and after the hearts had been removed from them. No trimming of the lungs and tracheae was done. The data are shown in table 22. Since the first year's results seemed to show rather clearly that there was little prospect of finding a breed difference in lung-and-trachea weight, no data on this point were collected during the second and third years.

TABLE 21.—*Comparison of average weights of untrimmed hearts, as removed from the steers, of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of final live-steer weights at feed lot*

1924–25 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	1.85	0.41	2.54	0.35	3.21	0.42
Shorthorn	2.00	.39	2.91	.38	3.22	.40
Brahman-Hereford	2.60	.36	2.97	.40	3.09	.39
Brahman-Shorthorn: First generation	2.35	.41	3.07	.39	3.51	.43

1925–26 EXPERIMENT

Hereford	1.80	0.40	2.53	0.37	----------	----------
Shorthorn	2.12	.40	3.05	.40	----------	----------
Brahman-Shorthorn:						
First generation	2.25	.39	3.20	.38	----------	----------
Second generation	2.15	.39	3.07	.39	----------	----------

1926–27 EXPERIMENT

Breeding	Steers fed Rhodes-grass hay 175 days		Steers fed hegari stover 175 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*	
Hereford, Shorthorn	[1] 3.61	0.42	[2] 3.52	0.40
Brahman-Shorthorn: First generation	[3] 3.85	.42	3.93	.43

[1] Average of 14 hearts. [2] Average of 19 hearts. [3] Average of 17 hearts.

TABLE 22.—*Comparison of the average combined weights of lungs and tracheae of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of the final live-steer weights at feed lot, 1924–25 experiment*

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	4.25	0.93	6.56	0.90	8.04	1.05
Shorthorn	4.70	.92	6.85	.90	7.95	.99
Brahman-Hereford	4.70	.85	6.84	.93	7.73	.97
Brahman-Shorthorn	5.10	.89	7.06	.90	8.32	1.01

WEIGHTS OF LIVERS, SPLEENS, AND SWEETBREADS

The livers were weighed as taken from the steers with only the trimming incidental to removing the gall bladders. The data pertaining to liver weights are given in table 23. As the first year's data showed no indication of a real difference between the part-Brahman and non-Brahman steers with respect to weight of livers, no further data were collected.

TABLE 23.—*Comparison of the average weights of the livers of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of the final live-steer weights at feed lot, 1924–25 experiment*

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	4.85	1.07	8.37	1.15	9.92	1.30
Shorthorn	5.75	1.13	9.20	1.22	10.96	1.36
Brahman-Hereford	5.80	1.05	8.64	1.17	9.95	1.24
Brahman-Shorthorn	6.40	1.12	9.83	1.26	10.36	1.26

Spleens were weighed only during the first year since there seemed to be no evidence of a breed difference. The data are shown in table 24.

TABLE 24.—*Comparison of the weights of spleens of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of the final live-steer weights at feed lot, 1924–25 experiment*

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	0.95	0.21	1.34	0.18	1.59	0.21
Shorthorn	[1] 1.45	.28	1.56	.20	[2] 1.90	.24
Brahman-Hereford	1.25	.23	1.50	.20	1.86	.23
Brahman-Shorthorn	1.15	.20	1.52	.19	2.01	.24

[1] This included 1 very heavy spleen weighing 2¾ pounds. There was no reason other than its very abnormal size for regarding this spleen as abnormal and consequently it was included in the calculations.
[2] The spleen from 1 steer was lost. The data for this group are based on 15 steers.

An attempt was made to weigh the sweetbreads (thymus) but difficulty was encountered in separating them neatly from the other tissues in the short time available during the procedure on the killing floor. Also the size of the sweetbreads was so much influenced by the age of the steers that there seemed to be little chance of determining breed differences even if such existed. After the second slaughtering the weighing of these organs was dropped from the procedure. The data are given in table 25.

TABLE 25.—*Comparison of the average weights of commercial sweetbreads (thymus) of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of final live-steer weights at feed lot, 1924–25 experiment*

Breeding	Steers at beginning of experiment		Steers fed 120 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*	
Hereford	1.40	0.31	0.49	0.07
Shorthorn	1.15	.22	.44	.06
Brahman-Hereford	1.25	.23	.37	.05
Brahman-Shorthorn	1.25	.22	.42	.05

WEIGHT OF STOMACHS AND WEIGHT AND LENGTH OF INTESTINES

The problem of making accurate comparisons of the stomachs of cattle is apparent to all persons familiar with the anatomy of ruminants. In a study of this kind the capacity of the stomachs is more important than the weight of the tissues. The weight of the full stomachs and their contents depends to a large extent on the variable quantities of feed and water contained which, incidentally, are much influenced by the length of time between the last feeding and slaughter.

A natural solution to the problem of making accurate comparisons of the stomachs of cattle would be some such method as measuring the capacities of the stomachs directly by emptying them, then filling them with water under water (to equalize pressure), and weighing or measuring the water thus contained. But such a procedure was impracticable for use on bovine stomachs at commercial packing plants. Accordingly the stomachs were weighed full, all four compartments together, just as they were taken from the steers. The weight of the weasand (esophagus) also was included in the weight of the stomach. To avoid delay, no trimming of fat, spleen, or other attached small parts was attempted. Data obtained on weights of stomachs and contents are given in table 26.

Consideration of weights of full intestines as measures of intestinal capacity involves difficulties similar to those mentioned in connection with weights of stomachs. The intestines (including attached fat and the pancreas) were weighed on the killing floor. The data obtained are shown in table 27. The intestines were also emptied and measured for length on two slaughtering occasions.

TABLE 26.—*Comparison of the average weights of the full stomachs of the non-Brahman and part-Brahman lots, expressed in pounds and as percentages of the final live-steer weights at feed lot*

1924–25 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	52.8	11.6	68.2	9.3	87.3	11.4
Shorthorn	65.0	12.8	85.1	11.2	104.2	13.0
Brahman-Hereford	56.5	10.2	59.9	8.2	68.3	8.5
Brahman-Shorthorn: First generation	74.9	13.1	63.1	8.1	64.6	7.9

1925–26 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 150 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	49.2	11.8	60.3	8.9	47.1	6.5
Shorthorn	57.0	10.7	72.2	9.4	46.7	6.0
Brahman-Shorthorn:						
First generation	50.8	8.8	63.8	7.6	49.6	5.8
Second generation	51.2	9.3	62.6	8.0	41.4	5.1

1926–27 EXPERIMENT

Breeding	Steers fed Rhodes-grass hay 175 days		Steers fed hegari stover 175 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*	
Hereford	90.8	10.3	97.3	11.3
Shorthorn				
Brahman-Shorthorn: First generation	84.2	9.1	89.0	9.7

TABLE 27.—*Comparison of the average weights of full intestines of non-Brahman and part-Brahman lots, expressed in pounds and as percentages of the final live-steer weight at feed lot*

1924–25 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	22.0	4.8	[1] 34.6	4.8	36.3	4.8
Shorthorn	23.8	4.7	34.5	4.5	40.7	5.1
Brahman-Hereford	22.2	4.0	31.0	4.2	32.9	4.1
Brahman-Shorthorn: First generation	22.5	3.9	27.7	3.6	33.1	4.0

1925–26 EXPERIMENT

Hereford	22.1	5.6	34.1	5.0	----	----
Shorthorn	23.0	4.3	34.3	4.5	----	----
Brahman-Shorthorn:						
First generation	23.4	4.0	31.9	3.8	----	----
Second generation	24.1	4.4	30.9	3.9	----	----

1926–27 EXPERIMENT

Breeding	Steers fed Rhodes-grass hay 175 days		Steers fed hegari stover 175 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*	
Hereford	40.6	4.6	41.3	4.8
Shorthorn				
Brahman-Shorthorn: First generation	38.8	4.2	38.0	4.1

[1] Intestines from only 6 animals included.

TABLE 28.—*Comparison of the average length of intestines of the experimental cattle, 1924–25*

Breeding	Steers at beginning of experiment		Steers fed 120 days	
	Small intestines	Large intestines	Small intestines	Large intestines
	Feet	*Feet*	*Feet*	*Feet*
Hereford	98.4	20.9	105.9	20.4
Shorthorn	99.4	21.6	115.5	21.5
Brahman-Hereford	97.1	21.4	107.6	22.6
Brahman-Shorthorn	98.9	21.6	107.6	21.4

WEIGHTS OF CAUL, RUFFLE, AND PAUNCH FATS

Comparisons of the caul, ruffle, and paunch fats were thought to be of value in interpreting differences in gains, dressing percentages, and apparent efficiency in the use of feed. Accordingly, observations were made of these internal fats. Caul fats were weighed on all seven slaughtering occasions. The data are given in table 29.

TABLE 29.—*Comparison of the average weights of caul fat of non-Brahman and part-Brahman lots, expressed in pounds and as percentages of the final live-steer weight at feed lot*

1924–25 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	2.95	0.65	5.25	0.72	6.67	0.87
Shorthorn	2.20	.43	4.70	.62	7.77	.97
Brahman-Hereford	2.35	.43	5.53	.76	8.64	1.08
Brahman-Shorthorn: First generation	2.70	.47	5.19	.67	7.90	.96

1925–26 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 150 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	2.20	0.56	6.62	0.98	6.68	0.93
Shorthorn	2.69	.50	8.04	1.05	10.77	1.39
Brahman-Shorthorn:						
First generation	1.30	.22	6.87	.82	9.65	1.14
Second generation	3.40	.62	9.23	1.18	9.75	1.19

1926–27 EXPERIMENT

Breeding	Steers fed Rhodes-grass hay 175 days		Steers fed hegari stover 175 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*	
Hereford	7.60	0.86	6.54	0.76
Shorthorn				
Brahman-Shorthorn: First generation	8.72	.95	9.80	1.07

Ruffle fats were weighed on all except the first slaughtering occasion. The data are given in table 30.

TABLE 30.—*Comparison of the average weights of ruffle fat of non-Brahman and part-Brahman lots, expressed in pounds and as percentages of the final live-steer weights at feed lot*

1924–25 EXPERIMENT

Breeding	Steers fed 120 days		Steers fed 179 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*	
Hereford	5.59	0.76	5.56	0.73
Shorthorn	5.07	.67	5.83	.73
Brahman-Hereford	5.51	.75	5.46	.68
Brahman-Shorthorn: First generation	4.70	.60	4.58	.50

1925–26 EXPERIMENT

Breeding	Steers at beginning of experiment		Steers fed 120 days		Steers fed 150 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*		*Pounds*	
Hereford	2.10	0.54	6.02	0.89	7.07	0.98
Shorthorn	2.31	.43	6.15	.80	9.20	1.18
Brahman-Shorthorn:						
First generation	1.70	.29	5.62	.67	7.64	.99
Second generation	2.75	.50	5.47	.70	6.73	.82

1926–27 EXPERIMENT

Breeding	Steers fed Rhodes-grass hay 175 days		Steers fed hegari stover 175 days	
	Average weight	Percentage of final weight of steer	Average weight	Percentage of final weight of steer
	Pounds		*Pounds*	
Hereford, Shorthorn	6.28	0.71	[1] 5.41	0.63
Brahman-Shorthorn: First generation	6.80	.74	[1] 6.14	.67

[1] Based on 24 ruffles, 1 not weighed.

Paunch fat, which is trimmed from the outside of the stomachs, was weighed on two slaughterings in the first experiment. The accuracy of this weight was affected considerably by the care used in trimming off small pieces of this fat. Accordingly, paunch fat was not weighed after the end of the first experiment and the data obtained, which incidentally showed no consistent differences, are not presented.

DISCUSSION OF DATA

Table 31 shows the statistically significant differences in the percentages which the weights of the various organs or parts constituted of the final feed-lot weights of part Brahmans as compared with non-Brahmans. These figures were obtained by averaging all

the comparable differences, giving equal weight to each such difference between lots. Connected with these differences and partially included in them were larger hide areas on the part Brahmans but heavier stomach and intestine contents in the non-Brahmans.

TABLE 31.—*Comparison of non-Brahman and part-Brahman cattle with respect to statistically significant differences in weights of various organs and parts*

Organ or part	Average excess percentage of organ or part based on live weight at feed lot	
	Part Brahmans	Non-Brahmans
Head (not including tongue)		0.145
Tongue		.085
Hide	0.280	
Tail	.017	
Full stomachs		1.860
Full intestines		.744
Warm carcass	2.230	

No statistically significant differences were found in hide thickness, intestine length, or in weight of heart, lungs, spleen, thymus, brain, leg bones and feet, or caul, ruffle, and paunch fat. The matter of hide thickness may deserve reexamination when a more satisfactory technic is developed for measuring hide thickness directly. However, not only did the direct measurements by calipers fail to reveal breed differences between part Brahmans and non-Brahmans in these experiments, but also the weights of the hides per square foot of area were not significantly different. Therefore the writers have considerable confidence in the general conclusion that breed differences in hide thickness are unimportant. There seems to be no definite literature on the normal variation in hide thickness.

Of the differences found, that in hide area is of little economic importance directly but may be of considerable physiological importance and may help explain why cattle of Brahman breeding thrive in hot climates. The larger area provides more radiating surface for disposing of the surplus heat produced by muscular exertion, digestion, and other metabolic activities.

The differences in weights of heads, tongues, and tails, although significant statistically, are too small to be important economically. The difference in carcass yield is very important economically and has long been recognized in a general way by the packers and commissionmen who are acustomed to cattle of Brahman breeding.

The differences in weight and capacity of the digestive tract go far toward explaining the higher carcass yield of the Brahmans. These differences apparently influence the feeding habits of the cattle and perhaps even affect digestive efficiency under certain conditions. Throughout these experiments the Brahmans had a distinct tendency to eat many times during the day but not a large quantity at any one time. The smaller capacity of their digestive tracts offers a plausible explanation for this peculiarity.

Weights of the same stomachs full at first and then emptied lead to the conclusion that the breed difference is primarily one of capacity rather than in the amounts of actual tissue present. It is frequently said that a large digestive tract is essential for large gains. The data of these experiments offered a chance partially to test this by comput-

ing the average intra-lot correlations between previous gain and full-stomach weights and full-intestine weights. The correlation between previous gain and full-stomach weights was +0.36 (279 degrees of freedom). That between previous gain and full-intestine weights was +0.53 (235 degrees of freedom). The correlation between full-stomach and full-intestine weights was +0.52 (235 degrees of freedom). These correlations indicate a distinct but far from perfect correlation between previous gain and capacity of digestive tract. These relations are complicated, however, by the fact that weights of stomachs and intestines include part of the observed gain in live weight and by the fact that weights of full stomachs and intestines are not perfect measures of capacity of the digestive tract.

The full intestines of the non-Brahmans constituted, according to the average of 11 differences between comparable lots, 0.74 percent more of the live weight of non-Brahmans than of the part-Brahmans. This difference is both statistically significant and commercially important. It parallels the difference in stomachs. These analyses of the data indicate a general difference in digestive tract rather than special differences in 1 or 2 digestive organs.

The percentages which some organs or parts constitute of the live weight depend much upon the steer's age and degree of fatness. Thus the thymus of the growing steer decreases rapidly even in absolute weight. It seems unimportant after weaning time. Head and leg bones, and in fact bony parts in general, increase in absolute weight during fattening but decrease as percentages of the live weight. On the contrary the heart remains almost a constant percentage of the live weight during fattening and the lungs actually increase faster than the live weight does. This observation suggests that a fat steer has need for more blood and oxygen supply per unit of actual living protoplasm than the thin steer does. The liver also becomes a larger percentage of the live weight as steers grow older and fatten.

During the first year there was a statistically significant difference between Herefords and Shorthorns in weight of liver but these groups had come from widely separated pastures and the difference may as well have been the result of pre-experimental treatment as that of genuine breed differences. This point was not followed further and is reported here only to record a clue for further attention at some future time.

Brahman characteristics which were completely recessive in inheritance, if there were any such, could scarcely have been detected in these experiments. Only the Shorthorn-Brahmans fed the second and third years could have shown such characteristics. Even here they would have appeared in only a few individuals and would have been obscured by the method of analysis which was largely a comparison of group averages. Doubtless the total number of genetic differences between Brahman and Hereford or Shorthorn cattle is enormously greater than the few indicated by the crosses studied in this experiment.

It is not surprising that only small differences in weights of organs and parts were found, especially since the experimental cattle were all of beef type. Swett, Graves, and Miller (*6*), who compared a highly specialized beef cow and a highly specialized dairy cow, report only small anatomical and structural differences. Though the external form of the two cows differed greatly, those investigators

found that "in weight and size of internal organs the differences were not sufficiently great to indicate significant differences in function."

ORGANS AND PARTS NOT RECOVERED AT SLAUGHTERING TIME

The total weight of the organs and parts weighed at slaughtering time of course was less than the live weight at the feed lot. Part of the weight not accounted for was the shrinkage during shipment. That ranged from as low as 3 percent for one shipment to about 7.5 percent for the three shipments during the second year. No doubt there was additional shrinkage between the time when the steers were weighed across the stockyard scales and the time they were actually killed. That interval was usually about 20 hours although it ranged from 2 to more than 30 hours. During this time the steers had access to water but not to feed.

No attempt was made to weigh the blood, which other studies have shown to be about 4 or 5 percent of the live weight. Even on the first two slaughtering occasions some of the smaller organs, such as the urinary bladder, were not weighed. After the first year, livers and lungs were omitted. At the sixth slaughtering occasion it was not feasible to weigh the heads nor any part of the full intestines except the ruffle fat. However, the procedure was always the same for all groups slaughtered on the same occasion. Differences between groups slaughtered at the same time are, therefore, comparable.

The percentage of the feed-lot weight obtained when the steers were weighed over the stockyard scales but not recovered on the killing floor varied at different slaughterings from 7.0 to 9.9 percent except on the one occasion when it was not possible to weigh the heads or the full intestines. Since the blood alone must have been about half of the weight unaccounted for, it is felt certain that there cannot have been an important difference in the weight of the parts not recovered.

The observed differences between part-Brahmans and non-Brahmans, both in shrinkage from feed lot to market and in shrinkage from the stockyard scales to the killing floor, are so small and so inconsistent (P is above 0.70 in both cases) that neither difference can be regarded as even suggesting significance. According to the data obtained, the stomachs and intestines of the Brahmans are distinctly smaller than those of the non-Brahmans even when the cattle are normally on pasture or in feed lots.

INDIVIDUAL VARIATION IN WEIGHTS OF ORGANS

Aside from fragmentary references no literature was found on the amount of variation normally to be expected in the weights or sizes of various organs and parts. To report such information for the use of future investigators, table 32 has been prepared. In it are shown the averages of the intra-lot standard deviations for most of the items on which slaughter data were obtained. This information is shown separately for the feeder calves and for the fat steers because the proportions of some of these organs or parts change rapidly with fattening or between the ages involved. Some organs or parts were weighed individually at every slaughtering occasion but others were weighed on only a few. Still others were sometimes weighed in

groups, thus making possible the averages which were the main object of the investigation but not providing any measure of the variation within the groups. Hence the amount of evidence on which these average standard deviations are based varies from item to item. For this reason table 32 shows the number of degrees of freedom, that is, the amount of information, on which each average standard deviation is based. The $n-1$ formula was used in computing these standard deviations. Sheppard's correction was not used.

TABLE 32.—*Intra-lot variation in weights or sizes of various parts or organs*

Part or organ	Feeder calves [1]		Fattened steers [2]	
	Degrees of freedom	Average intra-lot standard deviation	Degrees of freedom	Average intra-lot standard deviation
	Number		*Number*	
Head without tongue, pounds	31	1.91	117	1.37
Tongue, do	31	.63	117	.53
Hide area, square feet	30	4.22	161	3.28
Hide weight, pounds	30	7.10	255	6.82
Leg bones and feet, do	31	1.11	117	.90
Untrimmed hearts, do	31	.32	104	.30
Lungs and trachea, do	16	.39	90	.77
Liver, do	16	.88	90	1.24
Spleen, do	16	.44	89	.32
Thymus, do	16	.22	28	.12
Brain, do	16	.06	89	.08
Tail, do			90	.16
Full stomachs, do	31	11.14	261	12.05
Full intestines, do	31	3.23	200	5.51
Length of small intestine, feet	16	9.37	28	11.15
Length of large intestine, do	16	1.31	28	2.61
Caul fat, pounds	31	.88	254	2.53
Ruffle fat, do	15	.54	259	1.51
Paunch fat, do			90	.92

[1] There were 39 feeder calves in 8 groups. The average live weights of these groups at the ranch ranged from 392 to 578 pounds. The average for all the calves was 517 pounds.

[2] There were 281 fattened steers killed in 20 groups after 120 to 170 days on full feed. The average live weights of these groups at the ranch ranged from 678 to 922 pounds. The average for all the steers was 819 pounds.

So far as these various items were correlated individually with differences in live weight, the standard deviation actually found is larger than it would have been if the steers within each group had been more nearly identical in live weight than these actually were. Conversely, in any future experiment where the lots of steers are less uniform than these were, the standard deviations may be expected to be somewhat larger than the ones given in table 32. For example, the feeder calves killed at the beginning of the second experiment were selected to include both the large and the small individuals of their corresponding lots, in order to give representative averages for the feeder steers and yet to leave more uniform groups for the subsequent fattening. This selection of extremes to be slaughtered in the feeder group is largely responsible for the standard deviation for heads, hides, and leg bones being larger within the lots of feeder calves than within the lots of fattened steers.

No breed differences were found in the variability within lots but such differences would scarcely be expected since all the animals were either high grades or first crosses except the second-generation animals of the second and third years. These latter would theoretically have been expected to show more variability than the first

generation or high grades but the conditions of the experiment were such that significant differences of this kind could hardly have been found unless they were very extreme, especially since these double-cross animals were from selected first-cross parents.

The information in table 32 should help anyone planning the collection of similar data to decide what degree of precision would be desirable in weighing or measuring each item. A good general rule is that if the class interval is no larger than one fourth of the standard deviation, little information is gained by making the observations with still greater precision. For example, the standard deviation of the individual hearts was practically one third of a pound. Accordingly it would appear that anyone planning to study individual weights of hearts would lose a little information by weighing them only to the nearest tenth of a pound but that little would be gained by weighing them to a degree of precision farther than to the nearest sixteenth or to the nearest twentieth of a pound. On the other hand there would be little object in weighing hides any closer than to the nearest pound or in weighing the full stomachs closer than to the nearest 2 or 3 pounds. At the other extreme, anyone

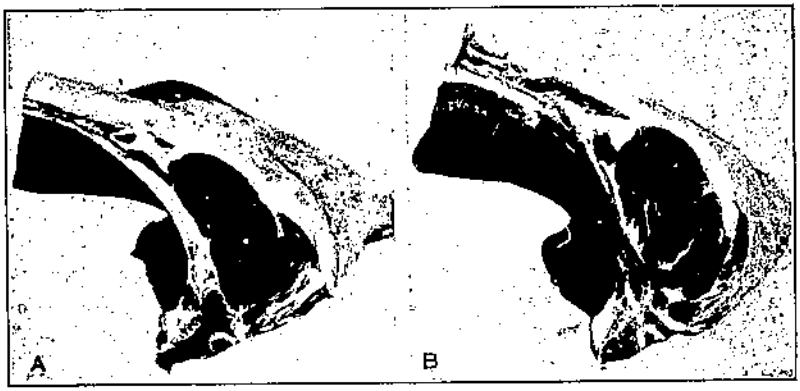

FIGURE 9.—Comparison of typical ribs from steers fattened 170 days: *A*, Rib from a Hereford carcass; *B*, rib from a Brahman-Hereford, 1924–25.

studying the individual weights of brains of cattle would need to count on weighing them at least to the nearest fiftieth of a pound and preferably to the nearest hundredth of a pound in order to utilize nearly all the information which is in the data.

COMPARISONS OF QUALITY AND PALATABILITY OF MEAT

PHYSICAL COMPARISONS OF CARCASSES AND THEIR PRINCIPAL DIVISIONS, 1924–25

In the first experiment, 1924–25, sides of representative carcasses from each lot were divided into wholesale cuts and these cuts were separated for purposes of comparison into bone, fat, and lean, under the direct supervision of the authors. This work was done in the packing plant at Fort Worth, where the cattle were slaughtered. The percentages of bone, fat, and lean and of various divisions of the hind quarters and fore quarters were determined, as shown in table 33. A comparison of two typical ribs is shown in figure 9.

TABLE 33.—*Comparison of bone, fat, and lean, and wholesale cuts, expressed as percentage of carcass, 1924–25*

Feeding period and breeding of steers	Carcasses	Carcass			Hind quarters						Fore quarters				
		Bone	Fat	Lean	Round	Rump	Loin	Flank	Kidney	Total	Ribs	Chuck and neck	Plate and brisket	Fore shank	Total
At beginning of experiment:	*No.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Hereford	2	25.29	4.90	69.84	23.60	4.28	17.57	3.09	0.78	49.32	9.78	25.14	10.27	5.49	50.68
Shorthorn	2	26.70	3.51	69.79	23.33	5.00	16.56	4.13	.76	49.77	9.45	24.55	10.23	6.00	50.23
Brahman-Hereford	2	23.70	3.88	72.42	22.72	5.07	16.54	3.00	.59	48.92	9.27	26.44	9.77	5.60	51.08
Brahman-Shorthorn	2	24.16	3.47	72.37	20.70	[1]	15.24	2.53	.73	48.20	9.75	25.90	10.85	5.30	51.80
Fed 120 days:															
Hereford	1	18.97	9.12	71.91	21.38	5.23	18.26	2.94	1.16	48.97	8.35	27.99	11.14	3.55	51.03
Shorthorn	1	19.16	7.97	72.84	21.61	5.16	16.30	3.60	1.33	47.12	9.95	27.87	10.72	4.34	52.88
Brahman-Hereford	1	18.79	6.36	74.94	22.42	4.61	16.26	3.15	1.52	47.96	9.25	26.73	11.64	4.52	52.04
Brahman-Shorthorn	1	19.50	7.16	73.74	23.08	4.74	17.70	3.08	1.07	49.67	9.23	24.92	11.45	4.73	50.33
Fed 179 days:															
Hereford	1	18.16	10.43	71.41	20.51	3.35	20.25	3.53	1.94	49.58	12.37	22.98	11.49	3.58	50.42
Shorthorn	1	18.08	10.82	70.50	20.59	4.43	19.22	3.54	1.37	49.15	12.22	21.70	12.93	4.00	50.85
Brahman-Hereford	1	16.34	11.24	72.42	20.10	3.54	19.21	4.46	1.94	49.25	11.76	23.67	11.93	3.39	50.75
Brahman-Shorthorn	1	19.24	7.53	73.23	23.70	3.82	17.69	3.16	1.57	49.84	10.34	24.03	11.30	4.49	50.16
Average:															
Non-Brahman	5	21.16	7.79	71.05	21.84	4.41	18.04	3.47	1.23	48.98	10.35	25.94	11.13	4.49	51.02
Part Brahman	5	20.27	6.81	73.10	22.40	4.36	17.09	3.38	1.25	48.97	9.93	25.28	11.14	4.67	51.03

[1] Round and rump combined.

CATTLE AND CARCASS GRADING AND LABORATORY STUDIES OF MEAT, 1925–27

After research work under the national cooperative meat project was inaugurated, the meat studies in the 1925–26 and 1926–27 experiments were associated with that project. During those years the cattle and carcasses were graded, and rib samples from typical steers in the various lots were forwarded to the laboratories of the United States Department of Agriculture at Beltsville, Md., and Washington, D.C., for study, including palatability tests of cooked meat.

GRADING OF CATTLE AND CARCASSES, 1925–27

The cattle and carcasses were graded individually by a committee composed of three members, representing the cooperating agencies. Each member graded each animal and carcass independently, and the average of the three gradings was taken as the official grade.

A grading chart was used to provide a means of assigning numerical values to all parts and characteristics of the animals and carcasses. The total of the values for an animal regarded as perfect would have been 100 points. The values assigned to the different items on the chart were based on 4-year average prices (1921–24) of wholesale beef cuts and carcasses, together with average weights of cuts expressed in percentages of weight. Thus the grading charts furnished a measure of the value of the steers and beef cuts on a practical market basis. The feeder grades used and the range of values representing each were: (1) Selected, 90+ to 100; (2) choice, 80+ to 90; (3) good, 70+ to 80; (4) medium, 60+ to 70; (5) common, 50+ to 60; and (6) inferior, 40+ to 50.

At the close of each feeding period the slaughter cattle and their respective carcasses were graded individually by the committee in a manner similar to that employed in grading the feeders. The slaughter-cattle and beef-carcass grades used and the range of values represent-

ing each were as follows: (1) Prime, 90+ to 100; (2) choice, 80+ to 90; (3) good, 70+ to 80; (4) medium, 60+ to 70; (5) common, 50+ to 60; (6) cutter, 40+ to 50; and (7) low cutter, 30+ to 40. Variations within grades were designated by "high", "middle", or "low", thereby providing a greater number of comparative terms. Table 34 shows the quality of the cattle, as expressed numerically under the grading system, for the 2 years during which grading was done. Table 35 provides a summary of the data for a more direct comparison of Herefords and Shorthorns with the Brahman crossbreds.

TABLE 34.—*Averages and ranges of numerical grades of feeder-cattle, slaughter-cattle, and beef-carcass grades*

Year, feeding period, and breeding of steers	Steers	Feeder grade		Slaughter grade		Carcass grade	
		Range	Average	Range	Average	Range	Average
1925–26							
At beginning of experiment:	*Number*						
Hereford	5			71.2–75.8	74.0	63.2–68.2	65.9
Shorthorn	4			70.6–77.5	74.1	59.6–67.3	64.9
Brahman-Shorthorn:							
First generation	5			67.5–72.3	70.0	60.4–65.8	63.3
Second generation	5			66.9–76.9	70.3	64.2–71.2	67.0
Fed 120 days:							
Hereford	6	78.9–91.5	83.6	74.6–83.4	78.8	69.2–78.9	72.4
Shorthorn	9	75.5–90.0	84.5	71.1–80.4	75.0	71.2–78.8	73.3
Brahman-Shorthorn:							
First generation	8	64.1–75.8	69.5	62.9–78.1	71.3	65.5–74.6	71.0
Second generation	8	65.9–78.4	71.9	66.7–76.2	70.4	67.5–73.5	70.6
Fed 150 days:							
Hereford	15	76.5–91.6	82.2	66.5–73.5	69.0	66.1–75.0	70.1
Shorthorn	10	76.1–89.4	81.2	61.5–74.7	68.9	65.0–75.9	71.2
Brahman-Shorthorn:							
First generation	13	64.3–71.3	68.2	60.9–73.6	67.3	60.2–72.0	69.4
Second generation	15	66.3–76.8	70.2	59.9–72.7	66.5	61.4–76.8	69.9
1926–27							
Fed 175 days:							
Hereford and Shorthorn (fed Rhodes-grass hay)	24	61.4–81.5	72.0	62.0–80.5	70.1	59.2–74.6	66.0
Hereford and Shorthorn (fed hegari stover)	25	67.1–78.5	71.4	57.1–77.5	68.8	57.7–70.1	64.1
Brahman-Shorthorn (fed Rhodes-grass hay)	24	64.6–73.0	67.7	61.5–75.9	69.1	57.9–71.3	66.2
Brahman-Shorthorn (fed hegari stover)	[1] 25	60.2–73.2	66.6	58.7–79.9	69.6	59.3–74.4	65.8

[1] 1 carcass not graded.

TABLE 35.—*Comparison of average grades of non-Brahman and part-Brahman cattle and their carcasses*

Feeding period and breeding of steers	Average grade as—		
	Feeders	Slaughter cattle	Carcasses
At beginning of experiment:			
Non-Brahman		74.1	65.4
Part Brahman		70.2	65.6
Fed 120 days:			
Non-Brahman	84.1	76.9	72.9
Part Brahman	70.7	70.9	71.1
Fed 150 days:			
Non-Brahman	81.7	69.0	70.7
Part Brahman	69.2	68.9	69.7
Fed 175 days:			
Non-Brahman	71.7	69.5	65.1
Part Brahman	67.1	69.4	66.0

LABORATORY STUDIES OF MEAT, 1925–26

From each lot of steers in the 1925–26 experiment, one representative or "standard" [3] rib sample was taken. These ribs were sent to the Department laboratories at Beltsville, Md., and Washington, D.C.

Physical and Chemical Analyses

A physical analysis was made of a sample consisting of the ninth, tenth, and eleventh ribs from the right side of the carcass. This was separated into "eye" muscle, other lean, fat, and bone. The various samples were then analyzed chemically for water, fat, and protein, with results shown in table 36. The corresponding portion of the left-rib cut was used for color comparisons and for cooking tests.

TABLE 36.—*Physical analyses of ninth, tenth, and eleventh rib samples and chemical composition of their edible portion, 1925–26*

Feeding period and breeding and number of steer	Physical analysis of entire sample					Chemical composition of edible portion		
	Edible portion				Bone			
	Lean		Fat	Total		Water	Fat	Protein
	Eye muscle	Other lean						
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
At beginning of experiment:								
Hereford, no. 16	27.9	38.9	9.4	76.2	23.8	65.2	14.6	19.6
Shorthorn, no. 7	30.1	37.8	8.6	76.5	23.5	64.8	16.3	18.4
Brahman-Shorthorn:								
First generation, no. 4	35.8	40.6	4.4	80.8	19.2	70.6	7.3	21.3
Second generation, no. 13	30.3	38.0	9.0	77.9	22.1	63.5	16.5	19.3
Fed 120 days:								
Hereford, no. 12	26.0	29.4	29.5	84.9	15.1	52.0	32.8	16.0
Shorthorn, no. 82	30.1	25.7	29.3	85.2	14.8	50.9	34.1	15.7
Brahman-Shorthorn:								
First generation, no. 52	20.2	33.3	21.9	84.4	15.6	54.4	28.9	16.4
Second generation, no. 44	25.0	31.5	29.0	85.5	14.5	50.4	34.2	15.7
Fed 150 days: [1]								
Hereford, no. 4	28.4	22.6	32.7	83.7	16.3			
Shorthorn, no. 89	30.4	22.4	31.3	84.1	15.9			
Brahman-Shorthorn:								
First generation, no. 69	31.0	23.0	31.6	85.6	14.4			
Second generation, no. 41	28.8	25.8	31.4	85.8	14.2			
Average:								
Non-Brahman	28.8	29.5	23.3	81.8	18.2	58.2	24.3	17.4
Part Brahman	30.0	32.1	21.2	83.3	16.7	60.7	21.7	18.2

[1] Chemical analysis of samples in third shipment incomplete.

Color Comparisons

In commercial channels, it is held that dark-red lean is less desirable than that possessing a brighter color. Consequently, the color of the lean portion of the eye muscle over the eleventh rib was compared with the standard color series adopted by the cooperators in these meat studies.[4] Since the series was not available at the time of the first shipment, the data obtained were for the second and third slaughterings. Comparisons were made 30 minutes after the muscle had been cut and exposed to the air. These results are reported in table 37.

[3] For description, see mimeographed outline of the cooperative meat project, A study of the factors which influence the quality and palatability of meat, issued for the cooperators by the Bureau of Animal Industry, U.S. Department of Agriculture.

[4] See footnote 3.

TABLE 37.—*Color of raw eye muscle of eleventh rib of certain steers compared with standard series of red, 1925–26* [1]

Breeding and steer no., and feeding period	Color	Breeding and steer no., and feeding period	Color
Hereford:		Brahman-Shorthorn:	
No. 12, fed 120 days	A6	First generation:	
No. 4, fed 150 days	A5	No. 52, fed 120 days	A8
Shorthorn:		No. 69, fed 150 days	A6
No. 82, fed 120 days	A5	Second generation:	
No. 80, fed 150 days	A5	No. 44, fed 120 days	A6
		No. 41, fed 150 days	A5
Average	A5.25	Average	A6.0

[1] A1 represents the lightest shade of red in this series, A10 the darkest.

COOKED-MEAT STUDIES

Standard rib samples from each lot, beginning with the first shipment of 1925–26 experimental animals, were cooked in a labora-

FIGURE 10.—An experimental rib roast. The thermometer registers the internal temperature and shows when the roast is done.

tory of the Bureau of Home Economics to determine (1) the loss in cooking and (2) the palatability.

Owing to a lack of laboratory ovens of uniform type when the four roasts from the first shipment of feeder samples were cooked, the cooking losses are not considered sufficiently comparable for publication.

The second and third shipments of steers in the 1925–26 experiment each provided four rib roasts. Laboratory ovens with glass doors and heat regulators had meanwhile been installed and were used in these and all subsequent tests. The roasts were seared for 35 minutes at oven temperatures averaging from 240° to 250° C., then cooked uncovered at 125° until the meat thermometer (fig. 10) registered 57°. Final meat temperatures ranged from 61° to 63.5°, the rise being due to the continued penetration of heat from outside

portions to the bulb of the thermometer in the center of the roast after removal from the oven.

Beef cooked in this way is rare, verging on medium-done. The slow oven temperature of 125° C. is used for palatability tests because it insures uniform cooking throughout a large proportion of a roast and thus provides comparably cooked slices for the judges.

LOSSES THROUGH DRIPPINGS AND EVAPORATION

The losses in cooking consist of the drippings loss, which is the weight of the mixture of fat and juice that cooks out of the meat and collects in the roasting pan, and the evaporation loss, which is the difference between total loss and drippings loss. Losses were calculated for each roast as percentages of the weight of the raw meat.

The cooking losses, or shrinkage, are less than they would be if the meat were roasted at the higher oven temperature ordinarily used in household cooking. The experimental data on cooking losses are shown in table 38.

TABLE 38.—*Cooking losses of the ninth, tenth, and eleventh rib samples, expressed as percentages of the weights of the uncooked roasts, 1925–26*

Feeding period, and breeding and steer no.	Weight of uncooked roast	Evaporation loss	Drippings loss	Total loss
Fed 120 days:	*Grams*	*Percent*	*Percent*	*Percent*
Hereford no. 12	3,535	9.1	4.6	13.7
Shorthorn no. 82	3,143	11.2	5.2	16.4
Brahman-Shorthorn:				
First generation no. 52	4,012	8.0	3.5	11.5
Second generation no. 44	3,310	10.0	5.3	15.3
Fed 150 days:				
Hereford no. 4	3,073	8.9	4.7	13.6
Shorthorn no. 80	2,986	7.7	5.6	13.2
Brahman-Shorthorn:				
First generation no. 69	3,331	8.4	4.9	13.3
Second generation no. 41	3,103	8.2	4.0	12.2
Average:				
Non-Brahman	3,184	9.2	5.0	14.2
Part Brahman	3,441	8.7	4.4	13.1

PALATABILITY STUDIES

Palatability studies were made on all the beef roasts by a cooked-meat grading committee consisting of several men and women of the Department's scientific staff. The members of the committee tasted slices from the eye muscle of the rib and portions of the inside fat of each hot roast, cooked and served without seasoning, and they compared the meat samples as to aroma, texture, flavor, tenderness, and juiciness. Cooked-meat grading charts were in process of development, but no numerical values had been assigned to the various descriptive terms, as was done in the tests of the following year. The data presented in table 39 represent the consensus of four judges' opinions on the merits of the cooked meat from representative steers of the lots designated.

TABLE 39.—*Palatability of ninth, tenth, and eleventh rib samples as determined by the cooked-meat grading committee, 1925–26*

Breeding and steer no., and feeding period	Aroma	Texture	Flavor of lean	Tenderness	Quantity of juice
Hereford:					
No. 12, fed 120 days	Good	Fine	Good	Tender	Fair.
No. 4, fed 150 days	do	do	do	Moderately tender	Small.
Shorthorn:					
No. 32, fed 120 days	Moderately undesirable.	Coarse	Fair	Moderately tough	Do.
No. 80, fed 150 days	Fair	Moderately fine	Good	Moderately tender	Large.
Brahman-Shorthorn:					
First generation:					
No. 52, fed 120 days	Undesirable	Moderately coarse	do	do	Do.
No. 44, fed 150 days	Good	Very fine	do	Tender	Do.
Second generation:					
No. 69, fed 120 days	Fair	Very coarse	do	do	Moderately large.
No. 41, fed 150 days	Good	Moderately coarse	do	Moderately tender	Small.

In tenderness the samples as judged by individuals varied from very tender to slightly tough. Quantity of juice ranged from large to small with various intermediate terms.

LABORATORY STUDIES OF MEAT, 1926–27

Standard rib samples from 3 carcasses in each of the 4 lots were sent to the Department laboratories at the close of the feeding period.

TABLE 40.—*Physical analyses of ninth, tenth, and eleventh rib samples from certain steers, and chemical composition of their edible portion, 1926–27*

Breeding and steer no.[1]	Physical analysis of entire sample					Chemical composition of edible portion		
	Edible portion				Bone			
	Lean		Fat	Total		Water	Fat	Protein
	Eye muscle	Other lean						
Hereford:	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
98	25.3	26.2	26.7	78.2	21.8	54.5	26.7	18.3
100	20.8	35.3	21.9	78.0	22.0	55.3	28.5	16.5
Shorthorn:								
17	25.7	24.4	26.7	76.8	23.2	52.4	30.7	16.9
21	24.4	31.6	15.5	71.5	28.5	58.2	23.2	18.2
24	26.3	23.1	30.4	79.7	20.2	48.6	35.9	15.1
76	26.6	30.3	13.2	70.0	29.9	59.0	20.8	18.3
Average	24.9	28.5	22.3	75.7	24.3	54.6	27.6	17.2
Brahman-Shorthorn, first generation:								
32	26.8	31.3	17.2	75.4	24.6	60.3	19.5	18.4
34	23.6	26.8	28.4	79.8	21.2	51.8	32.4	16.0
37	28.4	30.4	23.0	81.8	18.2	55.6	26.5	17.1
59	22.2	34.7	15.1	72.1	27.9	60.6	20.5	18.3
66	18.7	27.8	36.0	82.5	17.5	46.0	38.0	14.3
69	22.8	26.6	28.4	77.7	22.3	48.9	34.9	15.5
Average	23.8	29.6	24.7	78.1	21.9	53.8	28.6	16.6

[1] All steers fed 175 days.

Physical and Chemical Analyses

The methods of sampling and making the physical and chemical analyses conformed closely to those used the year before. Table 40 shows (1) the results of the physical analysis of the samples consisting of the ninth, tenth, and eleventh ribs from the right side of the carcasses, and (2) the chemical composition of the edible portion of the three-rib cuts.

Color Comparisons

The color variations of the eye muscle of the eleventh rib of the same steers are recorded in table 41. The method of making comparisons was the same as that used in the preceding year.

Table 41.—*Color of raw eye muscle of eleventh rib of certain steers, 1926–27, compared with standard series of red*

Breeding and steer no.[1]	Color [2]	Breeding and steer no.[1]	Color [2]
Hereford:		Brahman-Shorthorn; first generation:	
98	A5	32	A4
100	A4	34	A6
Shorthorn:		37	A1
17	A4	59	A9
21	A5	66	A5
24	A6	69	A2
76	A4		
Average	A4.7	Average	A4.5

[1] All steers fed 175 days.
[2] A1 represents the lightest shade of red in the series, A10 the darkest.

Cooked-Meat Studies

Three rib roasts from each of the four lots were cooked for palatability tests according to the standard directions of the cooperative meat project.[5] According to this method, which embodies minor changes from that of the preceding year, beef ribs are roasted in open pans. Each roast is first seared for 20 minutes in a hot oven, 260°–270° C., then cooked slowly at a greatly reduced oven temperature, 125°, until the thermometer placed in the meat registers 58°. The roast is then removed from the oven and allowed to stand until, through penetration of the heat from the outside portions, the temperature at the center of the roast, as measured by the thermometer, is 62–63°, which is the average maximum temperature reached under these conditions.

Losses through Drippings and Evaporation

Cooking losses of 1926–27 samples are shown in table 42.

[5] See footnote 3.

TABLE 42.—*Cooking losses of the ninth, tenth, and eleventh rib samples from certain steers, expressed in percentages of the weights of the uncooked roasts, 1926–27*

Breeding and steer no.[1]	Weight of uncooked roast	Evaporation loss	Drippings loss	Total loss
Hereford:	*Grams*	*Percent*	*Percent*	*Percent*
98	3,157	9.3	3.4	12.7
100	3,464	9.7	4.3	14.0
Shorthorn:				
17	3,702	9.5	4.5	14.0
21	3,341	10.8	3.3	14.1
24	4,720	8.8	4.5	13.3
76	2,895	10.5	2.5	12.9
Average	3,545	9.7	3.8	13.5
Brahman-Shorthorn; first generation:				
32	3,000	10.4	1.5	11.9
34	4,135	8.9	4.7	13.6
37	4,694	10.6	4.2	14.8
58	3,678	7.9	3.0	10.9
60	3,487	7.3	6.5	13.8
69	4,583	8.6	5.4	13.9
Average	3,924	9.0	4.3	13.2

[1] All steers fed 175 days.

PALATABILITY STUDIES

The roasts in the 1926–27 experiment were carved and sampled while hot, as in 1925–26. In recording their opinions, the judges used the official cooked-meat chart of the cooperative meat project. Aroma, flavor of fat, and flavor of lean were graded both for intensity and for desirability. Owing to the element of individual taste it is natural that desirability grades or expressions of preference should vary more, according to judges, than intensity grades. Other factors of palatability judged were the texture and tenderness of the meat and the quality and quantity of the juice. The figures presented in table 43 are the averages of the grades assigned by the 4 or 5 judges who ate the meat. In order to convey to the reader the significance of the figures, they are interpreted by the corresponding descriptive terms from the grading chart.

TABLE 43.—*Palatability* [1] *of ninth, tenth, and eleventh rib samples from certain steers as determined by the cooked-meat grading committee, 1926–27*

Breeding and steer no.[2]	Aroma		Texture	Flavor of fat	
	Intensity	Desirability		Intensity	Desirability
Hereford:					
98	4.8 Moderately pronounced	5.3 Moderately desirable	5.8 Fine	4.8 Moderately pronounced	5.5. Desirable.
100	5.3 Moderately pronounced	5.5 Desirable	4.0 Slightly coarse	4.3 Slightly pronounced	5.0. Moderately desirable.
Shorthorn:					
17	4.8 Moderately pronounced	5.0 Moderately desirable	4.8 Moderately fine	4.6 Moderately pronounced	4.8. Moderately desirable.
21	5.0 Moderately pronounced	5.8 Desirable	5.3 Moderately fine	5.0 Moderately pronounced	5.8. Desirable.
24	5.3 Moderately pronounced	5.8 Desirable	5.0 Moderately fine	4.8 Moderately pronounced	5.5. Desirable.
76	4.6 Moderately pronounced	5.0 Moderately desirable	5.0 Moderately fine	4.5 Moderately pronounced	5.0. Moderately desirable.
Average	4.9	5.4	5.0	4.6	5.3.
Braham-Shorthorn; first generation:					
32	5.3 Moderately pronounced	5.5 Desirable	4.8 Moderately fine	4.8 Moderately pronounced	5.0. Moderately desirable.
34	5.8 Pronounced	5.8 Desirable	4.8 Moderately fine	5.0 Moderately pronounced	5.8. Desirable.
37	5.6 Pronounced	5.6 Desirable	4.4 Slightly coarse	4.6 Moderately pronounced	5.2. Moderately desirable.
59	5.3 Moderately pronounced	6.0 Desirable	4.3 Slightly coarse	4.8 Moderately pronounced	5.8. Desirable.
66	5.8 Pronounced	5.3 Moderately desirable	4.8 Moderately fine	4.8 Moderately pronounced	5.3. Moderately desirable.
69	4.8 Moderately pronounced	5.6 Desirable	4.6 Moderately fine	4.6 Moderately pronounced	5.8. Desirable.
Average	5.4	5.6	4.6	4.7	5.5.

[1] The revised grading chart used by the committee provided a score of 7 as the maximum and a score of 1 as the minimum for each factor.
[2] All steers fed 175 days.

TABLE 43.—*Palatability* [1] *of ninth, tenth, and eleventh rib samples from certain steers as determined by the cooked-meat grading committee, 1926–27*—Continued

Breeding and steer no.[2]	Flavor of lean		Tenderness	Juice	
	Intensity	Desirability		Quality	Quantity
Hereford:					
98	5.3 Moderately pronounced	5.0 Moderately desirable	5.3 Moderately tender	4.5 Moderately rich	4.8 Moderately large.
100	5.0 Moderately pronounced	5.5 Desirable	5.5 Tender	5.0 Moderately rich	4.8 Moderately large.
Shorthorn:					
17	5.2 Moderately pronounced	5.4 Moderately desirable	5.5 Tender	4.4 Slightly rich	4.2 Slightly large.
21	4.8 Moderately pronounced	5.0 Moderately desirable	4.5 Moderately tender	4.5 Moderately rich	4.0 Slightly large.
24	5.0 Moderately pronounced	5.5 Desirable	4.3 Slightly tough	4.8 Moderately rich	4.5 Moderately large.
76	4.6 Moderately pronounced	5.2 Moderately desirable	5.6 Tender	3.8 Slightly rich	4.0 Slightly large.
Average	5.0	5.3	5.1	4.5	4.4
Brahman-Shorthorn; first generation:					
32	4.0 Slightly pronounced	4.8 Moderately desirable	4.5 Moderately tender	3.5 Slightly rich	3.8 Slightly large.
34	5.0 Moderately pronounced	5.3 Moderately desirable	4.8 Moderately tender	4.5 Moderately rich	4.5 Moderately large.
37	4.8 Moderately pronounced	5.6 Desirable	4.4 Slightly tough	3.8 Slightly rich	3.8 Slightly large.
59	4.3 Slightly pronounced	4.8 Moderately desirable	3.3 Tough	3.5 Slightly rich	3.8 Slightly large.
66	5.0 Moderately pronounced	5.0 Moderately desirable	3.8 Slightly tough	4.3 Slightly rich	4.5 Moderately large.
69	5.0 Moderately pronounced	5.4 Moderately desirable	4.8 Moderately tender	4.4 Slightly rich	4.8 Moderately large.
Average	4.7	5.1	4.2	4.0	4.2

[1] The revised grading chart used by the committee provided a score of 7 as the maximum and a score of 1 as the minimum for each factor.
[2] All steers fed 175 days.

Resistance to Shearing

Samples of both the cooked and the uncooked meat from this experiment were tested in a new device designed to record the resistance of the meat to shearing. The results are reported in table 44.

TABLE 44.—*Resistance to shearing of raw and cooked meat from certain steers*

Breeding and steer no.[1]	Resistance of eye muscle to shearing of—		Breeding and steer no.[1]	Resistance of eye muscle to shearing of—	
	Raw, right twelfth rib	Cooked, left eleventh rib		Raw, right twelfth rib	Cooked, left eleventh rib
Hereford:	*Pounds*	*Pounds*	Brahman-Shorthorn; first generation:	*Pounds*	*Pounds*
98	72	24	32	89	36
100	92	26	34	65	31
Shorthorn:			37	78	38
17	90	32	59	84	51
21	78	41	60	80	39
24	90	34	69	89	29
76	84	33			
Average	81.8	31.7	Average	80.8	37.3

[1] All steers fed 175 days.

This instrument, as described by Black, Warner, and Wilson (*1*), consists essentially of a steel blade drilled with a hole slightly larger than the sample of meat to be tested. The sample is placed in the hole and the blade is led through a narrow slot. A spring-type self-recording dynamometer registers the force required to pull the blade through the meat.

DISCUSSION OF DATA

A study of table 33, which compares the proportion of lean meat, bone, and fat of 16 experimental steers, shows the carcasses of the Brahman crossbreds to contain, on the average, slightly more lean and less fat and bone than the Herefords and Shorthorns. The relative weights of the wholesale cuts of the 16 steers varied but slightly, the most noteworthy difference, about 1 percent, being in the heavier loin of the non-Brahman steers.

The results of grading the cattle and carcasses also showed only small differences. Both as feeders and as slaughter cattle the Herefords and Shorthorns graded somewhat higher, on the average, but the differences in grades of carcasses were very much less and favored the Brahman crossbreds about as often as they did the non-Brahmans. In all groups of steers slaughtered directly from pasture, the average carcass grades were distinctly lower than the live-steer grades. In the case of fed cattle the differences between carcass grade and live-steer grades were less. In some instances the carcass grades were slightly higher.

Determinations of percentage of edible meat in carcasses or rib cuts were made in the case of 40 experimental steers, including both feeders and fat cattle, during the three experiments. The Brahman

crossbreds consistently yielded a slightly higher percentage of edible meat than the non-Brahmans.

In color of the meat, comparisons of the samples tested were variable and inconclusive. An average of numerical color readings slightly favored the Herefords and Shorthorns the first year these observations were made, but the next year they favored the Brahman crossbreds to a somewhat greater degree.

Comparisons of losses in cooking rib roasts likewise were variable. On the average, the losses were slightly higher for the meat of the Herefords and Shorthorns. The probable explanation lies in the somewhat greater moisture content of the average roast of these breeds of cattle, as it was observed that the roasts with the most moisture lost the most in weight through evaporation. Great variations were frequently observed, however, among individual roasts from cattle of the same breeding.

Data on the palatability of the cooked meat show only slight differences. According to the results obtained by the improved cooked-meat chart used in 1926–27, these differences favored the Hereford and Shorthorn roasts in flavor of lean and quality and quantity of juice. In flavor of fat the judges slightly preferred roasts of the Brahman crossbreds. These comments are based on average numerical ratings, but owing to the very slight differences, the limited number of samples, and natural variations in human judgment, the results do not warrant conclusions as to breed superiority on these points.

In texture of the cooked meat, however, roasts from the Brahman crossbreds were judged to be slightly but rather consistently coarser than those of the Herefords and Shorthorns.

In the mechanical test for tenderness (table 44) the raw meat from the Brahman-Shorthorns proved to be only slightly more tender than that of the Herefords and Shorthorns as a group. However, it was considerably more tender than the meat of the Shorthorns, with which it is more closely comparable. The resistance to shearing for the various groups was as follows: Brahman-Shorthorns, 80.8 pounds; Shorthorns, 89.3; Herefords, 67 pounds. The lower the resistance the more tender was the meat.

When cooked, the meat of the Brahman-Shorthorns was the least tender of the three lots, the resistance being 37.3 pounds as compared with 25 pounds for the Hereford and 35 pounds for the Shorthorn meat. However, the data show wide variations among individual animals in the different groups. Concerning this element of variation R. J. Kleberg, Jr., manager of the ranch, states in a personal communication:

> A careful study of the records of individuals of the crossbred cattle in this experiment shows that different individuals rate very differently in every respect, even as to tenderness, flavor, etc., in the meat studies. This shows clearly the possibilities for improvement which selection and breeding methods now offer to the energetic worker in this field.

For purposes of general comparison table 45 presents the essential results of the meat studies.

TABLE 45.—*Comparison*[1] *of raw and cooked rib roasts of non-Brahman and part-Brahman steers*[2]

Breeding	Intensity of color of eye muscle of rib	Small loss in cooking	Ease of shearing		Tenderness	Fineness of texture	Flavor of fat		Flavor of lean		Juice	
			Raw muscle	Cooked muscle			Intensity	Desirability	Intensity	Desirability	Quality	Quantity
Hereford and Shorthorn				++	++	++			++	+	++	+
Brahman-Shorthorn	+	++	+				+	+				

[1] +=very slight degree of superiority; ++=slight degree of superiority.
[2] Data on intensity of color and losses in cooking are for 1925–27; other data are for 1920–27.

SUMMARY AND CONCLUSIONS

During periods ranging from 1 to 3 years, crossbred Brahman-Hereford and Brahman-Shorthorn steers were compared with typical Hereford and Shorthorn steers, with respect to feed-lot performance, market desirability, size and weight of various parts of the body, and characteristics of the meat. Most of the experiments involving the Brahman-Shorthorns and the non-Brahmans were of 3 years' duration; those with Brahman-Herefords were for 1 year since Brahman-Hereford steers were not available after the first year. Most of the studies relating to the qualities of raw and cooked meat were of 2 years' duration and involved rib cuts from Brahman-Shorthorn, Shorthorn, and Hereford steers.

No significant differences were found in the total quantities of feed consumed in proportion to weight of the steers, but the Brahman crossbreds ate considerably more grain and cottonseed cake and a little more roughage per 100 pounds of gain.

The Brahman crossbred steers took a longer time to eat their feed than did the Shorthorns and Herefords.

Steers containing Brahman blood were heavier at weaning time than non-Brahman steers, and at that stage of development returned considerably more money per head. The price per hundredweight on the hoof was slightly higher, on the average, for the Brahman crossbreds.

At the end of 120 days' dry-lot feeding (based on an average of 2 years) the part-Brahmans sold at slightly higher prices per hundredweight and returned more money per head, even though their feed costs were slightly higher, whereas after feeding periods ranging from 150 to 179 days in length, there was a tendency for this condition to be reversed.

On account of gaining more and eating practically the same quantity of feed, the non-Brahmans made more economical feed-lot gains than the Brahman crossbreds.

No significant difference between Brahman crossbreds and non-Brahmans with respect to shrinkage while in shipment from feed lots to market was found.

The dressing percentages of Brahman crossbred lots ranged from about 2 to 4 percent higher (arithmetical difference) than those of Herefords and Shorthorns.

On account of smaller gains, greater feed consumption, and only slightly greater margins, the Brahmans are not so desirable feeders from the financial standpoint as the non-Brahmans, if purchased at the same price. However, the differences in feed-lot performance are small.

The dressed meat from the non-Brahman lots was appraised slightly higher than that from the Brahman crossbred lots, but this was about offset by the higher dressing percentage of the latter.

As noteworthy physiological and anatomical differences, the Brahman crossbreds had, on the average, smaller heads, larger hides, and smaller digestive tracts. The larger hides are explained by their loose and pendulous character, especially about the neck. The smaller digestive tract offers an explanation for the inclination of Brahman cattle to eat more frequently, and less at a time than Herefords and Shorthorns. Differences less significant from an economic standpoint were observed also in other parts and organs of the body.

Differences in the grading scores of the carcasses were too small to be significant.

The rib cuts from the Brahman crossbred steers had a slightly higher proportion of edible meat and a correspondingly smaller proportion of bone than the rib cuts from the other lots. There was no consistent difference in the chemical composition of the edible portion nor in the color of the meat.

In grading cooked meat the committee found only slight differences in the palatability of meat from the Brahman crossbreds and the non-Brahman steers. The texture of the meat from the former was rather consistently coarser than that from the Herefords and Shorthorns. The meat from the Brahman crossbreds was judged to be slightly less tender than that of the Herefords and Shorthorns. Minor differences in cooking losses through drippings and evaporation appeared to be independent of the breeding of the cattle.

Taking into consideration the various factors in cooking and palatability and varying tastes of the judges, the cooked meat of part-Brahman and non-Brahman steers is considered to be approximately equal in desirability.

Though necessarily the data presented are based on averages for the experimental cattle, individual records of the animals and their meat varied materially. Such variations, in the light of well-established principles of animal breeding, strongly indicate the possibility of improving types of beef cattle both in feed-lot efficiency and quality of meat.

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