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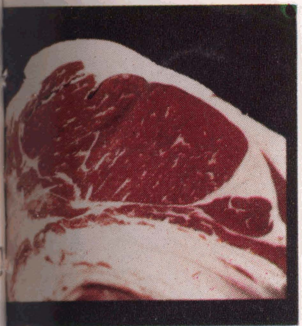

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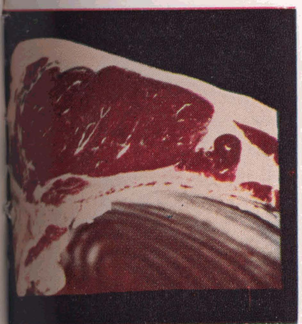

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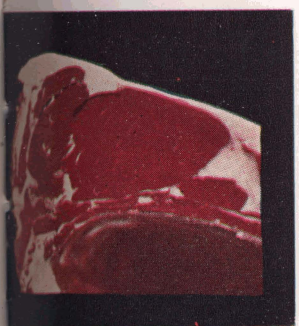

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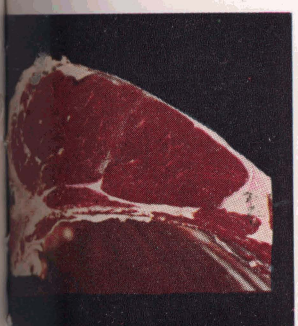

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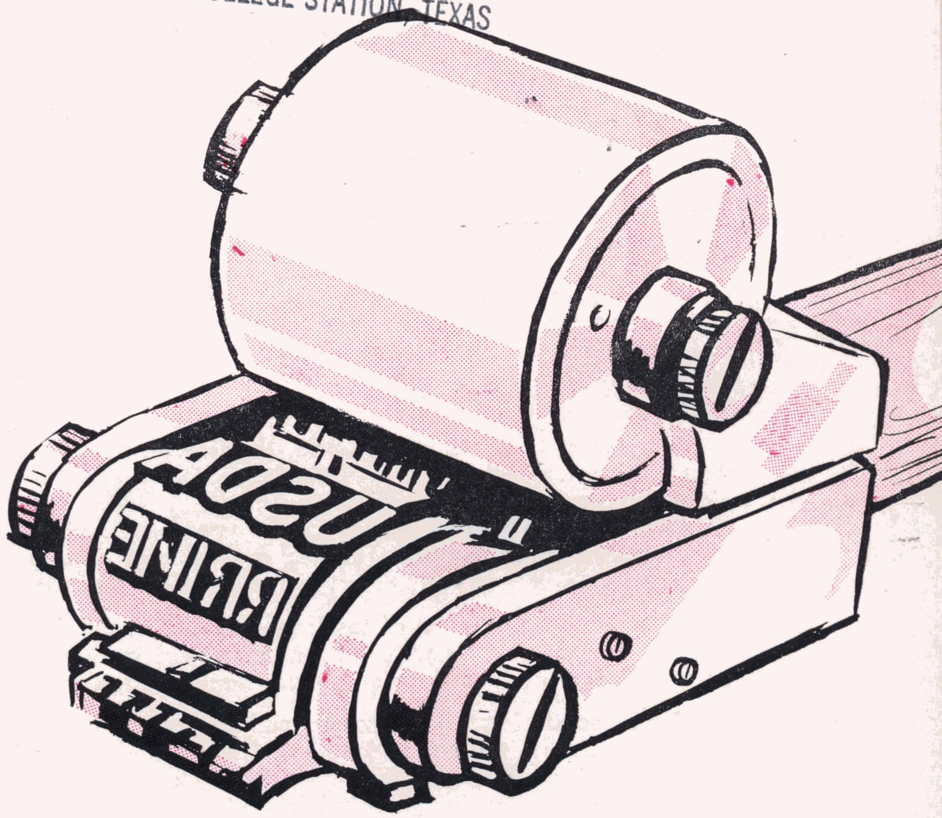

EFFECT OF CARCASS GRADES AND FATNESS ON TENDERNESS OF MEAT FROM STEERS OF KNOWN HISTORY

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SUMMARY

Studies were conducted by the Departments of Home Economics and Animal Husbandry in which tenderness data of loin steaks broiled well-done under standardized conditions were obtained from 203 steers. Of this number, 126 were produced and fed and 77 were fed under controlled conditions. All cattle were graded to one-third grade by the area supervisor of the USDA Meat Grading Branch for the Texas-Oklahoma area.

No attempt was made to obtain an equal number of animals from each grade. Instead, production variables were standardized and the carcass grades which resulted were one of the outcomes of research on the production of these animals. These 203 carcasses graded: 1 Prime, 19 Choice, 96 Good, 73 Standard, 13 Utility and 1 Cutter. Two measurements were obtained for the degree of fatness of the carcass—percent separable fat in 9-10-11 rib cut and percent ether extract of the trimmed ribeye from the 9-10-11 rib cut. Percent separable fat measures the visible fat, and percent ether extract is a chemical measure of marbling. Tests for tenderness were made by a taste panel and by a mechanical tester called the Warner-Bratzler shearing device.

Results of these tests are shown in scatter diagrams. The tenderness rating of each carcass was plotted against its carcass grade or its fatness. Wide scattering of tenderness ratings were observed for different animals within a grade. Tenderness ratings were as high for meat from some carcasses in the lower grades as for meat from other carcasses in the higher grades. These observations indicate that carcass grades under the present standards were not satisfactory as an exact indicator of tenderness in the meat of this sample of 203 carcasses.

If an exact indicator of tenderness were available, it might be incorporated in the carcass grade standards. This puts on research workers the burden of finding the causes of tenderness or toughness, and of developing satisfactory methods of identifying them.

Wide scattering of tenderness ratings for meat from different carcasses also was observed with the two measures of fatness. The agreement between fatness and tenderness was low enough so that it is not surprising that a consumer who buys fat or even well-marbled loin steaks sometimes is disappointed in their tenderness.

Coefficients of correlation were calculated for tenderness rating with carcass grade, separable fat and ether extract. The coefficients were low and not consistent as to sign.

CONTENTS

Effect of Carcass Grades and Fatness on Tenderness of Meat from Steers of Known History

SYLVIA COVER, G. T. KING and O. D. BUTLER *

TENDERNESS IS ONE of the most important qualities of beef from a consumer's view-[...]t. Yet the causes of tenderness or toughness [...] poorly understood, and no visible characteris-[...]is known which is thoroughly reliable as an [...]icator of tenderness in beef. Thus the con-[...]er is faced with a difficult problem when she [...]hes to buy tender beef.

[W]hen studies on tenderness of meat were [...]ted at this Station in 1933, it was thought that [...]and loin cuts could be relied upon for tender-[...]s if they came from fat animals of beef breed-[...]and from high grade carcasses. If such cuts [...]e not tender after cooking, then "a poor [...]k spoiled good meat." This idea is still [...]valent. Further studies with standardized [...]hods of cooking and with animals varying in [...]ess and carcass grades are causing many re-[...]ch workers to modify their statements about [...] reliability of certain visible characteristics as [...]icators of tenderness.

The first data from a Texas study to arouse [...]bts about the closeness of the relationship of [...]cass grades to tenderness were published in [...]7 (2). In this study, 9-10-11 rib roasts were [...]ked well-done at a constant oven temperature [...]257°F. The carcass data for these animals ap-[...]ared only in the appendix. Carcass grades and [...]derness scores of these individual animals [...]e been plotted with each dot representing one [...]mal (Figure 1). Had there been a nearly [...]fect relationship between higher carcass [...]des and higher tenderness scores, the dots [...]ld have clustered closely about a line running [...]m the lower left-hand corner to the upper [...]ht-hand corner. This does not occur, but a [...]ht trend of this sort may be observed. The [...]derness scores within a grade were widely [...]ttered and they indicated that the meat from [...]e carcasses in the lower grades was as tender [...]that from other carcasses in the higher grades. [...]parently, tender meat was not limited to beef [...]m the higher grade carcasses. From a tech-[...]al point of view, this early work may now be [...]ticized. The judging panel was not constant [...]her in numbers or in personnel, but such panels [...]e common in other laboratories at that time. [...]se cuts were obtained from a packing house [...] Fort Worth and had been shipped to College [...]tion under variable refrigeration, and the aging conditions could not be controlled for the different carcasses. Age, breeding, management factors and, in some cases, sex, were unknown. These are obvious defects in the early data and no conclusions were drawn at that time on the relationship of carcass grade to tenderness, but the data aroused doubt and curiosity about this relationship.

Research information concerning this problem has been accumulating for some time at the Texas Station as a by-product of several projects. Carcass grades were available for all of the beef which has been used for studies in the Foods Laboratory in recent years, although they were seldom referred to in previous publications on tenderness. Data on carcass grade and tenderness may be extracted from four studies in which conditions had been standardized. In these studies, the experimental animals were either produced and fed, or were fed, and the storage conditions of the carcasses were standardized. However, no attempt had been made to obtain an equal number of animals in each grade. Instead, production variables were standardized and the carcass grades which resulted were one of the outcomes of research on the pro-

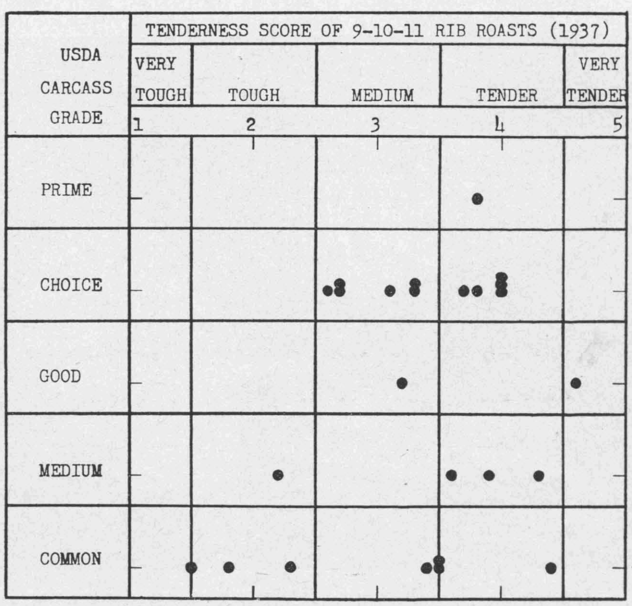

Figure 1. Carcass grade plotted against tenderness score (5-point scale) of 9-10-11 rib roasts cooked well-done to an internal temperature of 80°C. (176°F.) at a constant oven temperature of 125°C. (257°F.). Each dot represents one animal.

[R]espectively, professor, Department of Home Economics; [...]l assistant professor and head, Department of Animal [Hu]sbandry.

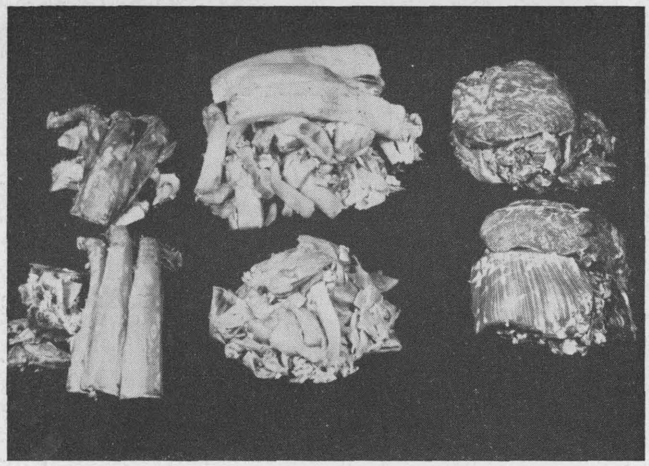

Figure 2. Separations of 9-10-11 rib cut into bone, fat and lean. Top, from U. S. Prime carcass; bottom, from U. S. Standard carcass. Note the similarity in the size of the piles of lean and bone from Prime and Standard cuts. The stack of fat from the Prime grade cut is more than twice as large as that from the Standard grade.

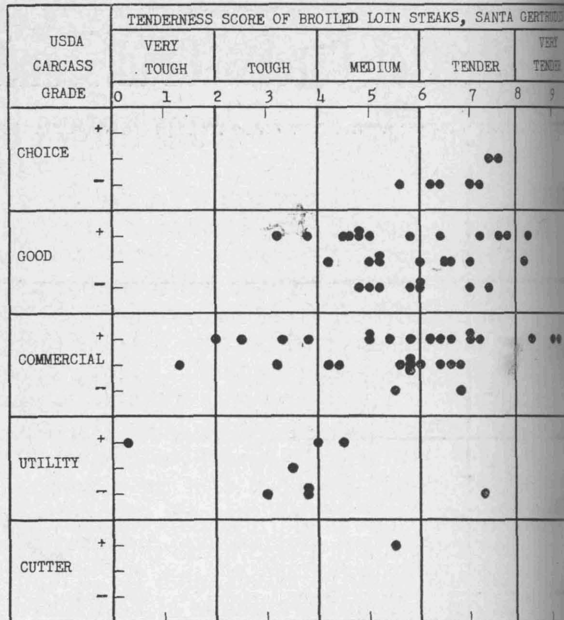

Figure 4. Carcass grade plotted against tenderness score (11-point scale) of loin steaks broiled well-done, Santa Gertrudis steers, 1954 and 1955. Each dot represents one animal.

duction of these animals. In these four studies, 126 animals were produced and fed and 77 were fed under controlled conditions. All cattle were graded to one-third grade by the area supervisor of the USDA Meat Grading Branch for the Texas-Oklahoma area. The carcasses graded: 1 Prime, 19 Choice, 96 Good, 73 Standard, 13 Utility and 1 Cutter.

In addition to data on carcass grades, two measures of fatness were obtained on the 203 carcasses—percent separable fat in the 9-10-11 rib cut and percent ether extract of the trimmed ribeye from the 9-10-11 rib cut. The 9-10-11 rib cut was made along the bony structure according to precise directions to provide uniformity of cutting among many animals. Separations were then made into fat, lean and bone (Figure 2). The percentage of separable or visible fat in this cut was calculated. Ether extracts the fatty substances in meat and the percentage of the ether extracted material from muscle samples is a chemical measure of marbling. Since the percent ether extract was obtained on the trimmed eye muscle from the 9-10-11 rib cut, it was thought

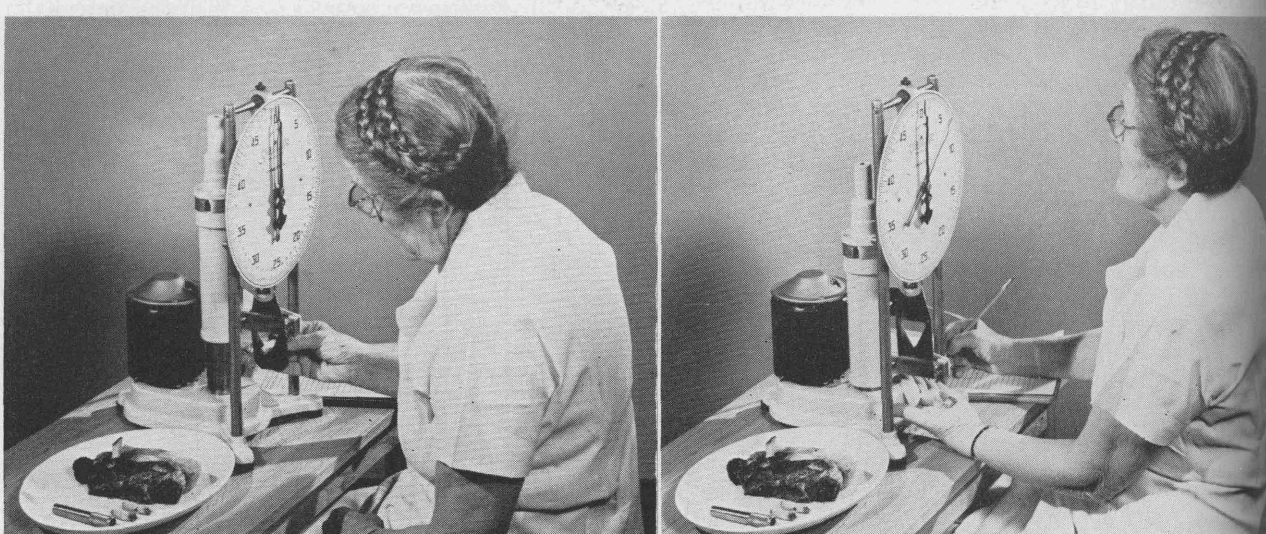

Figure 3. The Warner-Bratzler shearing device for testing the tenderness of meat. The V-shaped knife is connected to the dial and passes through a slot in an extension of the housing. Before shearing is begun, this slotted portion must be raised above the V-shaped knife and the hands on the dial must be in the zero position. LEFT—Cylindrical samples of meat (cores) were taken following carefully the grain of the meat. One of these cores is held loosely in the V-shaped knife so the cut will be made across the grain of the meat. RIGHT—Electricity has been applied and the slotted portion has been pulled downward pressing the meat so tightly into the V-shaped knife that it has been cut through. Note that the meat is in two pieces and that the force needed to do the cutting (shearing) was registered in pounds on the dial.

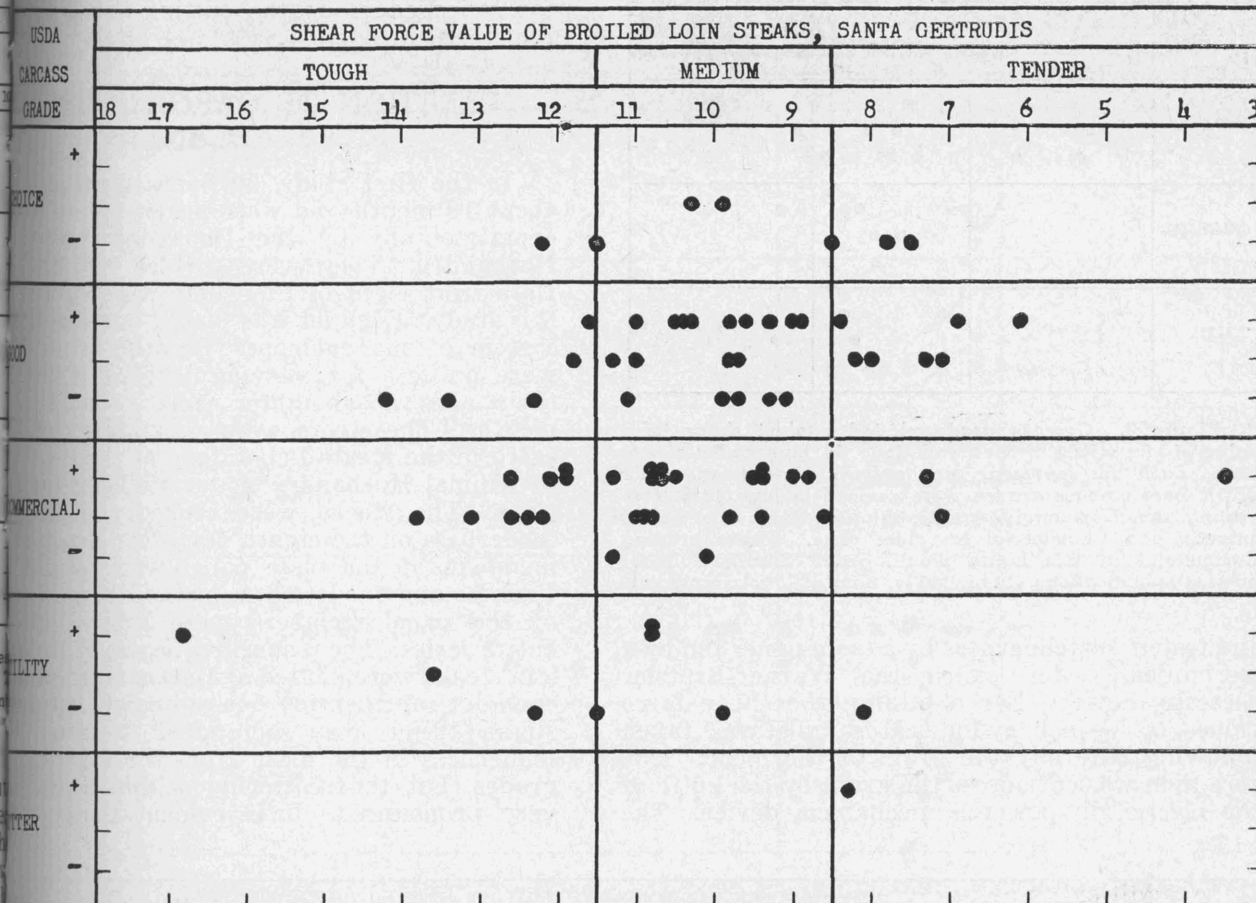

Figure 5. Carcass grade plotted against shear force value of loin steaks broiled well-done, 77 Santa Gertrudis steers, and 1955. Each dot represents one animal. Statistically, $r = -.218$, not significant.

be closely related to the marbling of ribeye ich is a major criterion of grade determina- n. These data do not include an equal number animals with each percentage of separable fat each percentage of ether extract. In these data, as in the data on carcass grades, the percentages obtained were one of the outcomes of research on the production of these animals.

For testing tenderness, loin steaks were broiled well-done under standardized conditions

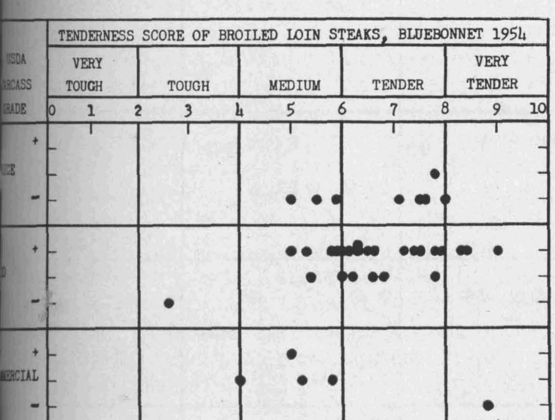

Figure 6. Carcass grade plotted against tenderness re (11-point scale) of loin steaks broiled well-done, 38 bonnet steers, 1954. Each dot represents one animal. ecifications for USDA beef carcass grades were revised in e 1956, separating the Commercial grade into Standard young animals and Commercial for older ones. Steers ding Commercial in this figure would grade Standard der present specifications.

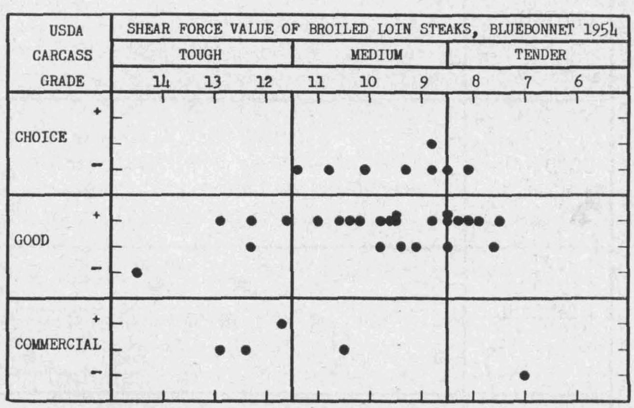

Figure 7. Carcass grade plotted against shear force value of loin steaks broiled well-done, 38 Bluebonnet steers, 1954. Each dot represents one animal. Specifications for USDA beef carcass grades were revised in June 1956, separating the Commercial grade into Standard for young animals and Commercial for older ones. Steers grading Commercial in this figure would grade Standard under present specifications. Statistically, $r = -.252$, not significant.

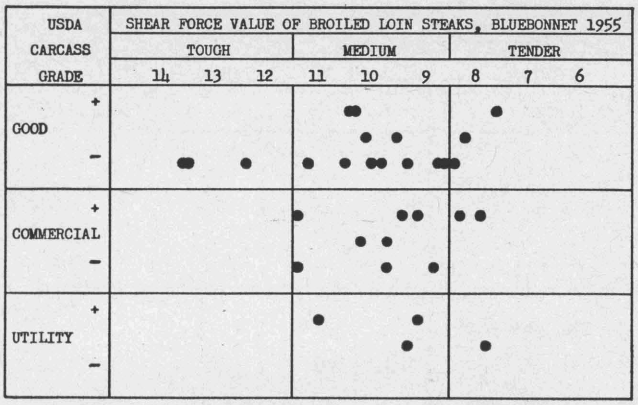

Figure 8. Carcass grade plotted against shear force value of loin steaks broiled well-done, 31 Bluebonnet steers, 1955. Each dot represents one animal. Specifications for USDA beef carcass grades were revised in June 1956, separating the Commercial grade into Standard for young animals and Commercial for older ones. Steers grading Commercial in this figure would grade Standard under present specifications. Statistically, r = .120, not significant.

and tested for tenderness by a taste panel and by a mechanical tester called the Warner-Bratzler shearing device. For obtaining the shear force values, a ½-inch cylindrical sample was taken following carefully the grain of the meat. This core then was cut across the grain by the knife of the electrically-powered mechanical device. The force needed to do the cutting (shearing) w registered in pounds on a dial (Figure 3).

RELATION OF CARCASS GRADE TO TENDERNESS

In the first study, 90 Santa Gertrudis ste about 10 months old were purchased and treat experimentally by the Department of Anim Husbandry. They were divided into nine lo Data from eight of these lots were available i this study. Each lot was placed under a differe system of management. Because of this, th were on test for varying lengths of time a their ages at slaughter were about 14 to months. The steers were slaughtered and pr essed in the Meats Laboratory of the Departme of Animal Husbandry under standardized con tions. The steaks were cooked and tested f tenderness on the eighth day after slaughter. members of the taste panel were present ea time for any one lot of animals. Most, but not of the panel members were available for t entire series. The tenderness scores of the broil loin steaks were plotted against carcass grade wi each dot representing one animal (Figure 4). slight trend may be noted toward grea tenderness in the meat from the higher carca grades, but the scattering within a grade w very pronounced. It is evident that a carca

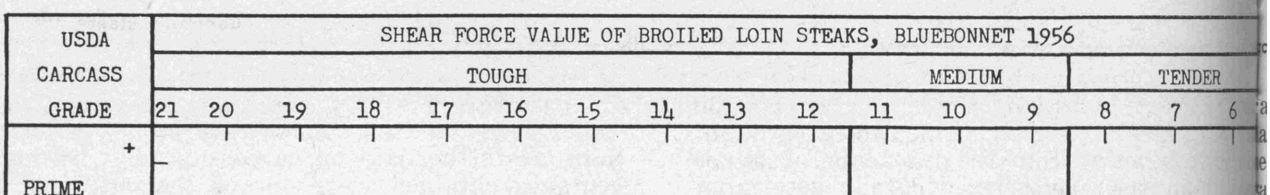

Figure 9. Carcass grade plotted against shear force value of loin steaks broiled well-done, 57 Bluebonnet steers, 1 Each dot represents one animal. Statistically, r = —.360, significant at 1% level.

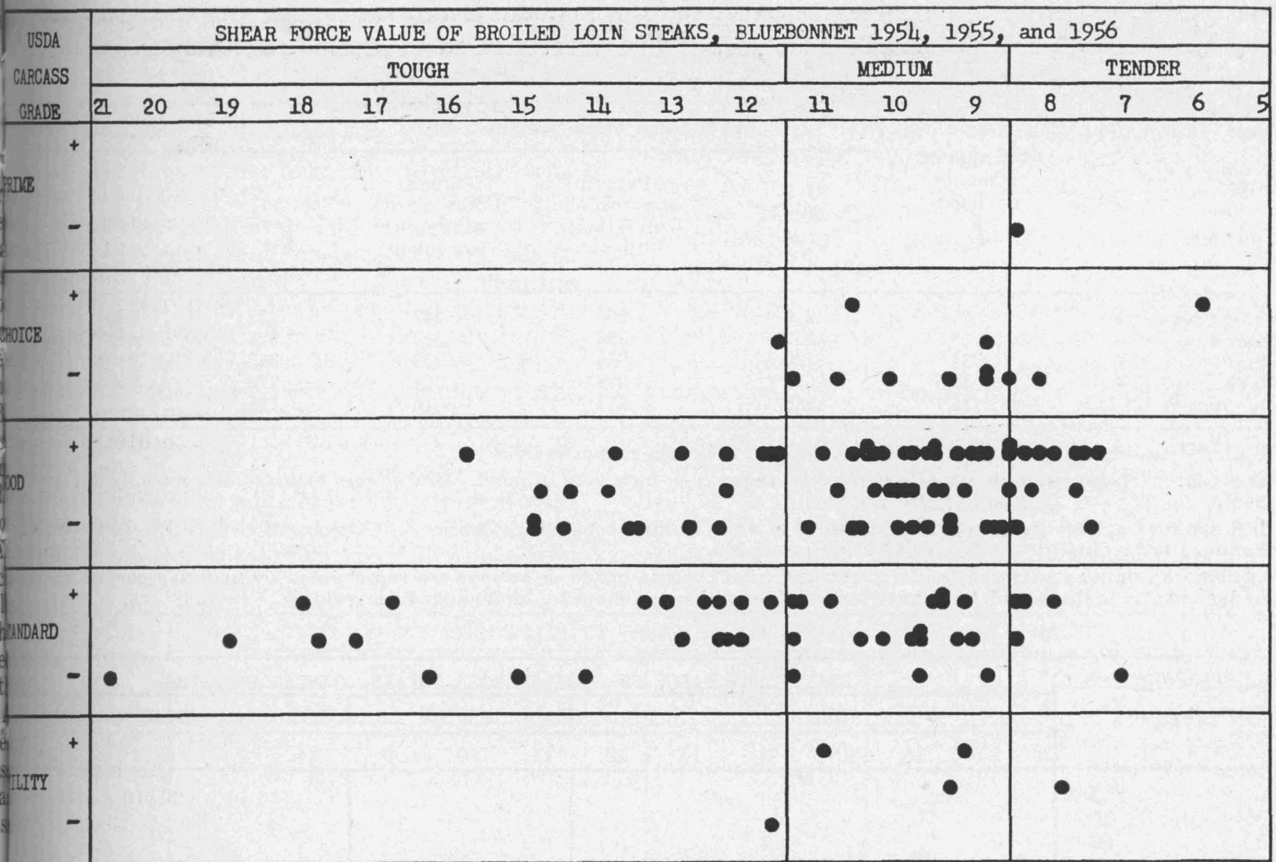

Figure 10. **Carcass grade plotted against shear force value of loin steaks broiled well-done, 126 Bluebonnet steers, 1954-56.** h dot represents one animal. **Statistically, r = —.226, significant at 5% level.**

ade was not homogenous for tenderness and t tender meat was not confined to carcasses of higher grades. Similar conclusions may be wn from the shear force data (Figure 5).

Steers were obtained in 1954, 1955 and 1956 m Substation No. 23 at McGregor, Texas. eir history was known "from conception to sumption." These yearling steers were known the "Bluebonnet steers," and will be so re- red to in this report. They had been on rate- gain tests and all in each year's test were ghtered within a period of 1 week and proc- ed in the Meats Laboratory. The ages at ghter were 13 to 16 months. Specifications USDA beef carcass grades were revised June 6, separating the Commercial grade into ndard for young animals and Commercial for er ones. Steers grading Commercial in these s would have graded Standard under present cifications. The steaks were obtained on the enth day after slaughter, wrapped, frozen at 0°F. and stored at 0°F. until the tests could made.

The sires of the 1954 Bluebonnet steers were refords and Brahmans, but all the dams were h grade Herefords. All of the taste panel e persons) were present each time for this . The trend toward greater tenderness with higher grade carcasses shows many excep- tions (Figure 6). The corresponding shear force values allow a similar interpretation (Figure 7). Note that the meat from a carcass in the lowest of these grades (low Commercial) scored next to the highest for tenderness and sheared the most tender.

The 1955 Bluebonnet steers were of mixed breeding. The 31 animals included: 4 Hereford, 5 Santa Gertrudis, 4 Holstein, 4 Brahman x Hereford, 2 Santa Gertrudis x Hereford, 3 Santa Gertrudis x (Brahman x Hereford), 4 Red Poll x Hereford, 4 Red Poll x (Brahman x Hereford) and 1 Jersey x Brahman. Tenderness scores from the taste panel are not available for these animals. The shear force values show no indication that the more tender meat came from carcasses of the higher grades (Figure 8). In fact, there seems to be a slight trend in the opposite direction.

Fifty-seven Bluebonnet steers were tested in 1956. There were 6 Santa Gertrudis, 9 Herefords, 10 Brahmans and 32 Brahman-Hereford crosses. Figure 9 shows a trend toward more tender meat from the higher grade carcasses, but tenderness was not limited to the meat from such carcasses.

Because the Bluebonnet steers for 1954, 1955 and 1956 were of approximately the same age and had been treated in a similar manner, the shear force data for these three groups were combined.

TABLE 1. CORRELATION OF SHEAR FORCE VALUE OF LOIN STEAKS BROILED WELL-DONE WITH U. S. CARCASS GRADE AND FATNESS

Identity of the steers	Number of steers in each test	Coefficients of correlation				
		Shear force value[1] versus			Needed for significance	
		U. S. carcass grade [2] [3]	Percent separable fat in 9-10-11 rib cut [3]	Percent ether extract of ribeye, dry basis [3]	5% level *	1% level **
Santa Gertrudis	77	—.218	—.080	—.247*	.232	.302
Bluebonnet 1954	38	—.252	—.296	—.330*	.325	.418
Bluebonnet 1955	31	.120	.064	—.238	.349	.449
Bluebonnet 1956	57	—.360**	—.299*	—.304*	.273	.354
Bluebonnet 1954,5,6	126	—.226*	—.259**	—.312**	.195	.254

*, **, *** indicate significance at 5%, 1% and 0.1% levels, respectively.

[1]Shear force values were in pounds needed to shear a ½-inch core of meat. Low shears mean tender meat, high shears tough meat.

[2]U. S. carcass grades were coded to one-third of each grade as follows: Canner 1-3, Cutter 4-6, Utility 7-9, Commercial 10- Standard 13-15, Good 16-18, Choice 19-21, Prime 22-24.

[3]Positive correlations between tender meat and high carcass grade or fatness are represented by negative coefficients because tender meat is indicated by low shear force value, and tough meat by high shear force value.

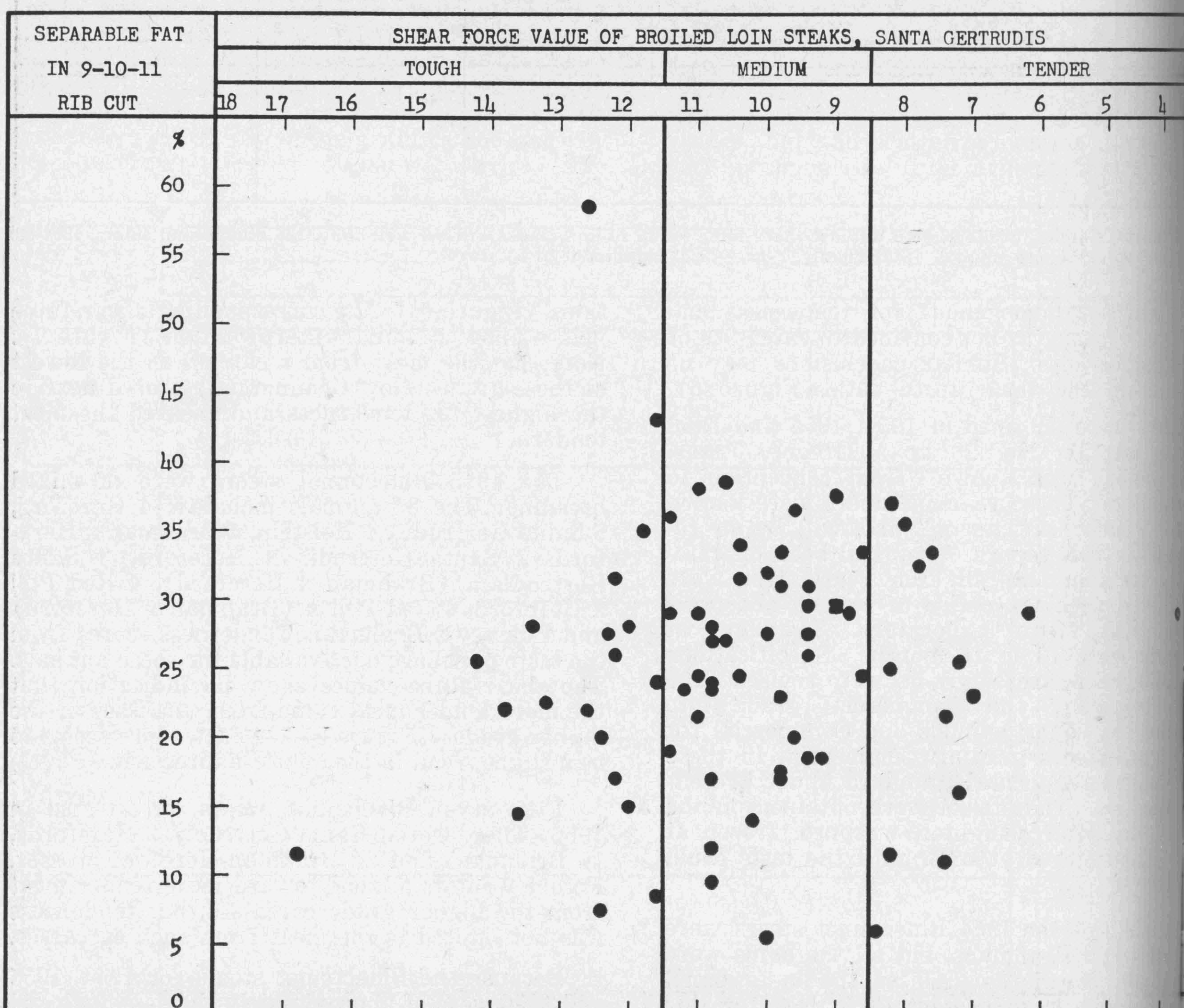

Figure 11. Percentage separable fat in 9-10-11 rib cut plotted against shear force value of loin steaks broiled well-done, 77 Santa Gertrudis steers, 1954-55. Each dot represents one animal. Statistically, r = —.080, not significant.

This gave a total of 126 yearling steers. There seemed to be a trend toward more tender meat in the higher carcass grades, but tenderness of loin steaks, broiled well-done, was not limited to meat from such carcasses (Figure 10).

For research workers who are familiar with statistics, part of this story may be told concisely by correlation coefficients. The closeness of the relationship between tenderness score and shear force value is indicated by the correlation coefficient −.839 (loin steaks, broiled well-done, 1954 Bluebonnet steers). This was not only highly significant, but it indicates that the shear force value accounts for more than 70 percent of the variation in tenderness score. In contrast, the relationship between shear force value and U. S. carcass grade in the same carcasses is low (−.252). It is higher and statistically significant with 1956 Bluebonnet data, but high grade was associated with tough meat in the 1955 data and with tender meat in the 1956 data (Table 1). When the Bluebonnet data from the 3 years were combined, the relationship was low (−.226). A correlation coefficient of −.226 indicates that less than 5 percent of the variation in shear force value was associated with carcass grade, leaving more than 95 percent unaccounted for. Thus, carcass grade appeared to be unsatisfactory as an indicator of tenderness in the meat of this sample of 126 yearling steers.

It would be highly desirable to be able to identify tenderness variations more adequately than is now possible with carcass grades. Carcass grades are based on conformation, finish and quality. Conformation denotes shapes and is indicated by the degree of fullness, plumpness, thickness and width of the rounds, loins, ribs and chucks. Finish is indicated by thickness of fat covering, uniformity in the distribution of fat, firmness of fat and amount of internal fats. Quality is indi-

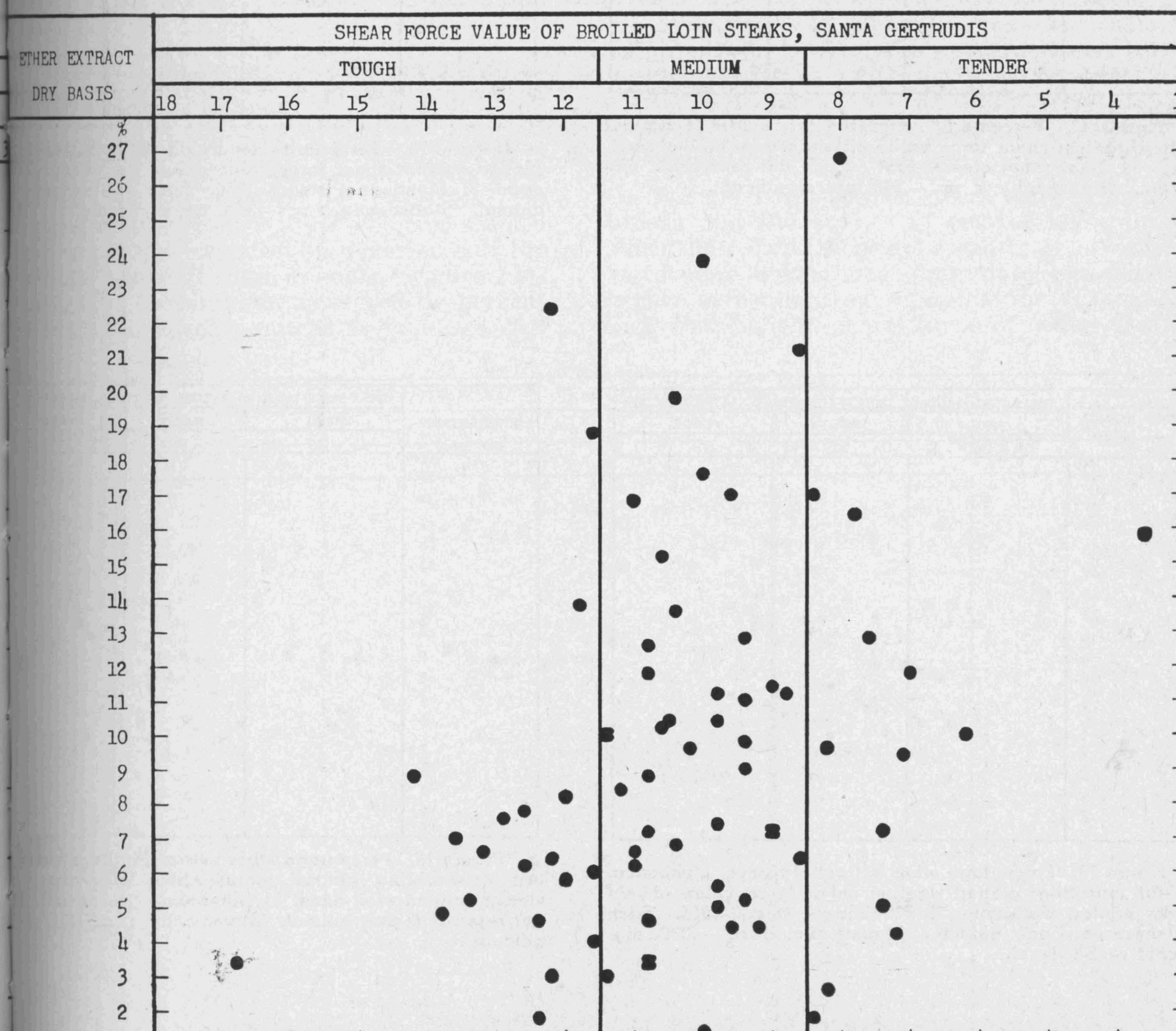

Figure 12. Percentage ether extract of ribeye, a chemical test for marbling, plotted against shear force value of loin steaks broiled well-done, 77 Santa Gertrudis steers, 1954-55. Each dot represents one animal. Statistically, r = −.247, significant at 5% level.

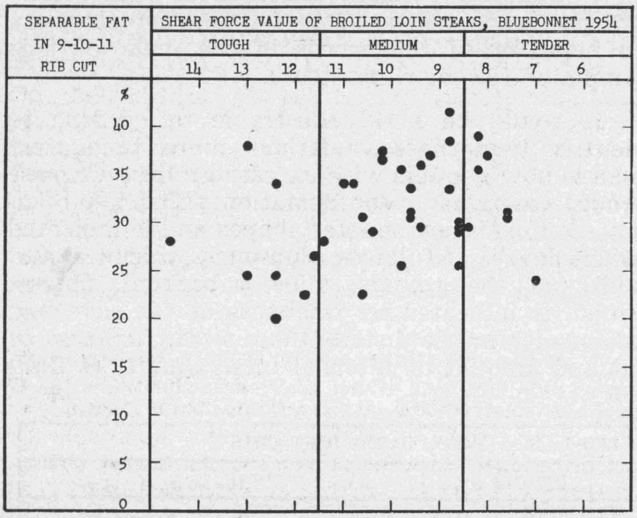

Figure 13. Percentage separable fat in 9-10-11 rib cut plotted against shear force value of loin steaks broiled well-done, 38 Bluebonnet steers, 1954. Each dot represents one animal. Statistically, r = —.296, not significant.

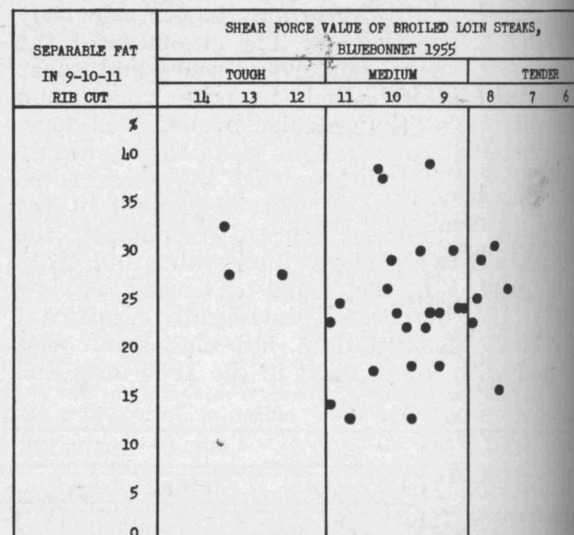

Figure 15. Percentage separable fat in 9-10-11 rib c plotted against shear force value of loin steaks broiled we done, 31 Bluebonnet steers, 1955. Each dot represents o animal. Statistically, r = —.064, not significant.

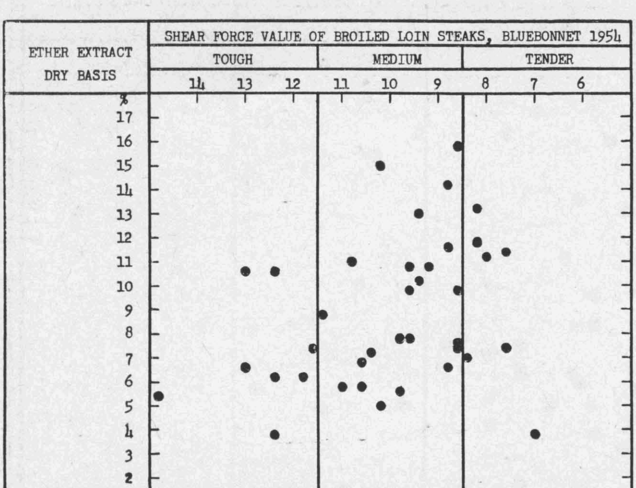

Figure 14. Percentage ether extract of ribeye, a chemical test for marbling, plotted against shear force value of loin steaks broiled well-done, 38 Bluebonnet steers, 1954. Each dot represents one animal. Statistically, r = —.330, significant at 5% level.

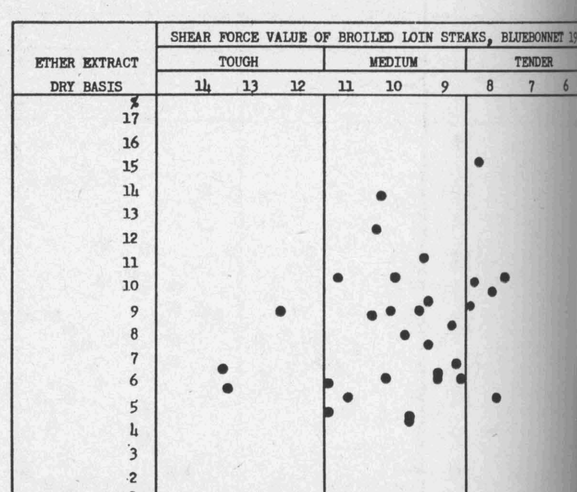

Figure 16. Percentage ether extract of ribeye, a chemic test for marbling, plotted against shear force value of lo steaks broiled well-done, 31 Bluebonnet steers, 1955. Ea dot represents one animal. Statistically, r = —.238, not si nificant.

cated by degree of marbling, texture, firmness of lean and color of flesh. Degree of bone ossification is used to estimate the maturity classification of the carcass. Since fatness is an essential part of two of the three bases on which carcasses are graded, it seemed possible that fatness might be more closely related to tenderness than was carcass grade.

RELATION OF FATNESS TO TENDERNESS

That the tenderness of beef increases with fatness has been believed widely for a long time. Laboratory measurements of fatness at the Texas Station included percent separable fat in the 9-10-11 rib cut and percent either extra of the trimmed ribeye in the 9-10-11 rib cut. Separable fat is a measure of fat deposition between the muscles and on the surface of the rib cut. It is one indication of "finish." Percent ether extract may be regarded as a chemical measure of marbling, which in turn is a major indication of "quality."

The Santa Gertrudis steers differed widely in carcass grade (Choice to Cutter). This variation was associated with differences in fatness since they had been subjected to different systems of management which allowed wide differences in fatness. Yet separable fat in the 9-10-11 rib cut, which ranged from 6 to 57 percent, seemed to have no measurable effect on tenderness of the broiled loin steaks of these animals (Figure 11). The degree of marbling, as measured by percent ether extract and which ranged from 1.2 to 26.9 percent, seemed to have some effect on the tenderness of the meat of these steers (Figure 12). Yet the tenderest meat came from a carcass with 28 percent separable fat and 15.8 percent ether extract.

The 1954 Bluebonnet steers were produced under uniform conditions. They were Herefords and Brahman x Hereford crossess. The Brahman x Hereford steers were longer of leg and body than the Herefords. These considerations affected the grade; therefore, grade differences were not due entirely to variations in fatness. Separable fat of the 9-10-11 rib cut did not appear to influence the tenderness of the broiled loin steaks from these animals (Figure 13), yet there seemed to be a slight trend toward greater tenderness with the higher degree of marbling (Figure 14).

The 1955 Bluebonnet steers differed even more widely in breeding than those in 1954. Greater tenderness was not obtained from carcasses having the higher percent separable fat (Figure 15). In fact, the opposite trend toward greater tenderness with lower fatness was indicated. But there was a slight trend toward greater tenderness with the higher degree of marbling (Figure 16).

The 1956 Bluebonnet steers were from three breeds and the crosses of two of these breeds. With these data, there appeared to be a trend toward more tender meat from carcasses with the higher percentages of separable fat (Figure 17) and the higher percentages of ether extract

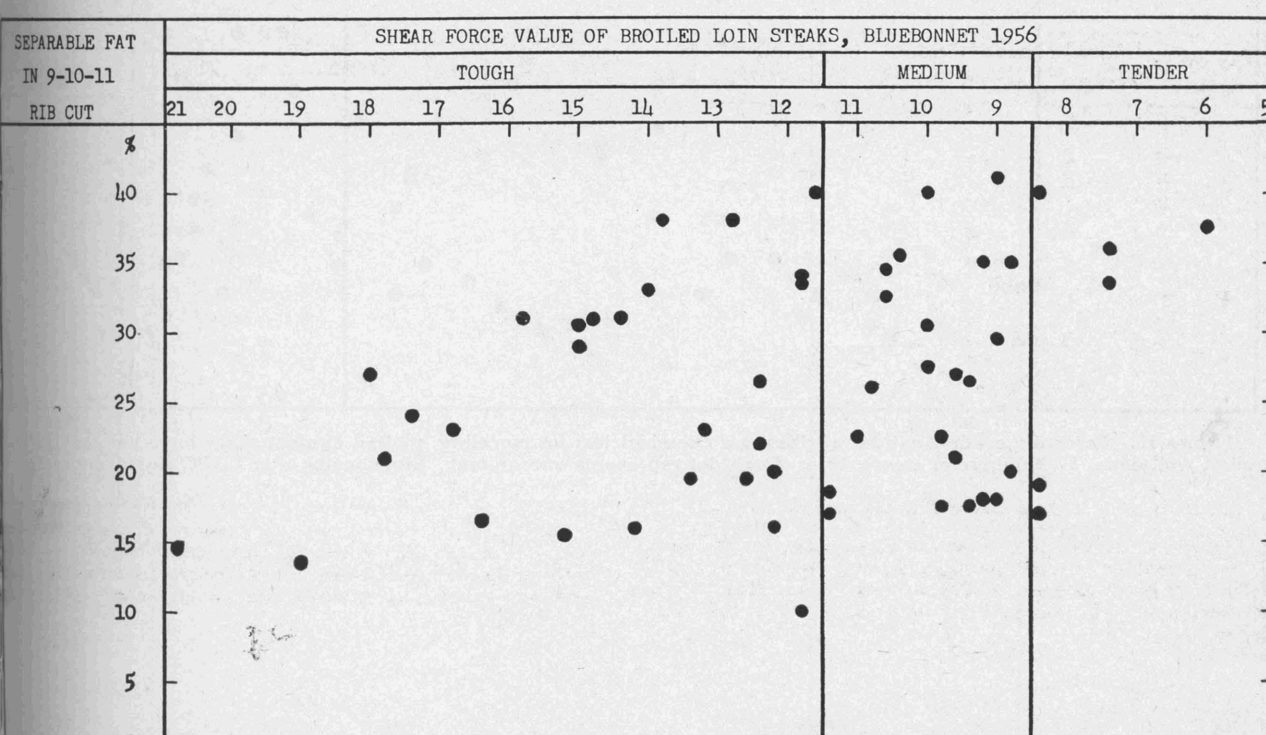

Figure 17. Percentage separable fat in 9-10-11 rib cut plotted against shear force value of loin steaks broiled well-done, [illegible]7 Bluebonnet steers, 1956. Each dot represents one animal. Statistically, r = —.299, significant at 5% level.

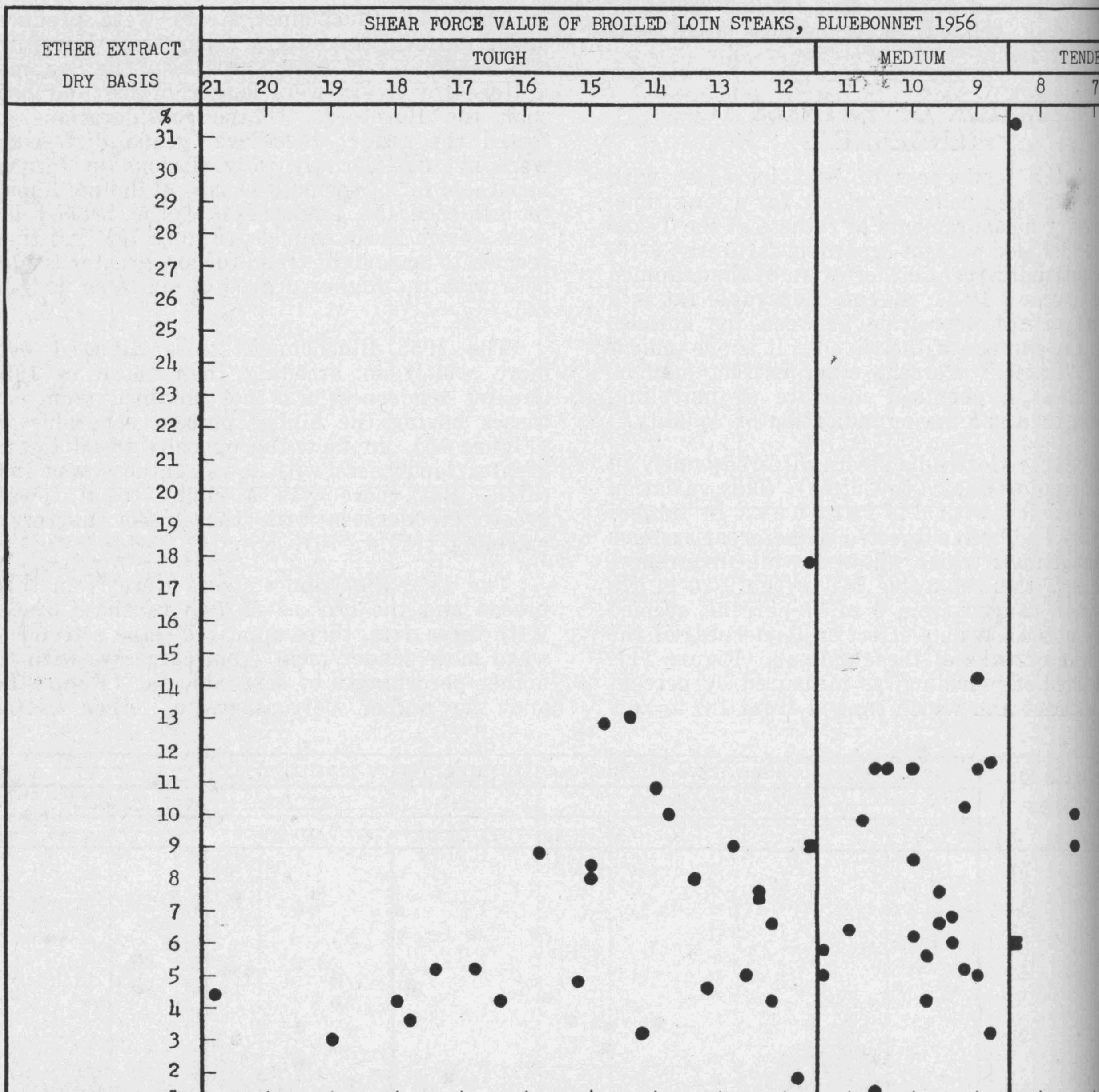

Figure 18. Percentage ether extract of ribeye, a chemical test for marbling, plotted against shear force value of loin steaks broiled well-done, 57 Bluebonnet steers, 1956. Each dot represents one animal. Statistically, r = —.304, significant at 5% level.

(Figure 18), although one carcass with extremely high percent ether extract (31.4) had meat no more tender than others with much lower ether extract (9.0, 10.0 and 12.6 percent).

All of the Bluebonnet steers were yearlings, 13 to 16 months of age, and all were produced under similar conditions, although they differed widely in breeding. When the data were combined, there was a tendency toward greater tenderness in meat from carcasses with higher percent separable fat (Figure 19) and higher ether extract (Figure 20). But some animals with less marbling (as low as 3.8 percent ether extract) were as tender as the one with the most marbling (31.4 percent ether extract).

The statistical treatment of tenderness versus fatness for loin steaks broiled well-done is given in Table 1. Although some of the coefficients of correlation for separable fat versus shear force value were significant, the highest (—.299) accounted for less than 9 percent of the total variation, leaving more than 91 percent of the variation in shear force value unaccounted for. Not only were the coefficients low for these individual lots of animals, but one of them carried a different sign.

Ether extract often seemed to be significantly correlated with shear force value, but here too the highest (—.330) accounted for less than 11 percent of the total variation, leaving more than 89 percent of the variation in shear force value unaccounted for. These coefficients were not only low, the ones for separable fat were not consistent in sign. Cover, Butler and Cartwright (3) reported more details for the 1954 Bluebonnet cattle. Hankins and Ellis (7) in 1939 reported even lower correlations (—0.108±.025) between ether extract of ribeye and shear force value of 9-10-11 ribs roasted rare.

The agreement between fatness and tenderness was low enough so that it is not surprising that a consumer who buys fat or even well-marbled loin steaks is sometimes disappointed in their tenderness. Conversely, a consumer who buys loin steaks lower in fat and marbling from carcasses of lower grade sometime may be pleased with their tenderness.

DISCUSSION

Tenderness probably is controlled by many factors. Although a few of these factors may be included among those used in determining carcass grade, some not considered also must be important. This must be so because different animals within a carcass grade had tenderness ratings which differed widely instead of being close together or homogenous within a grade. Carcass grades are designed to classify things other than tenderness and exact tenderness classification should not be expected in the absence of exact indicators of tenderness. However, if an exact indicator of tenderness were available, it might be incorporated in the carcass grade standards. This puts on research workers the burden of finding the causes of tenderness

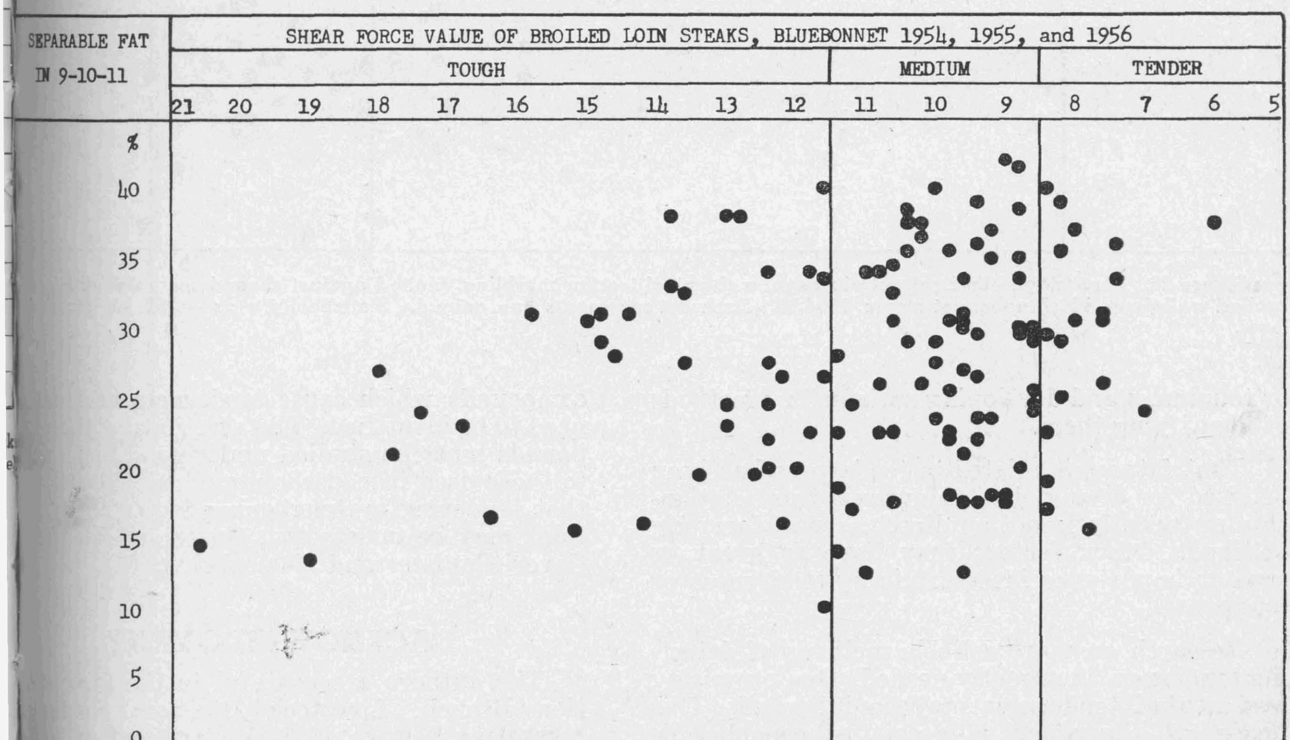

Figure 19. Percentage separable fat in 9-10-11 rib cut plotted against shear force value of loin steaks broiled well-done, Bluebonnet steers, 1954-56. Each dot represents one animal. Statistically, r = —.259, significant at 1% level.

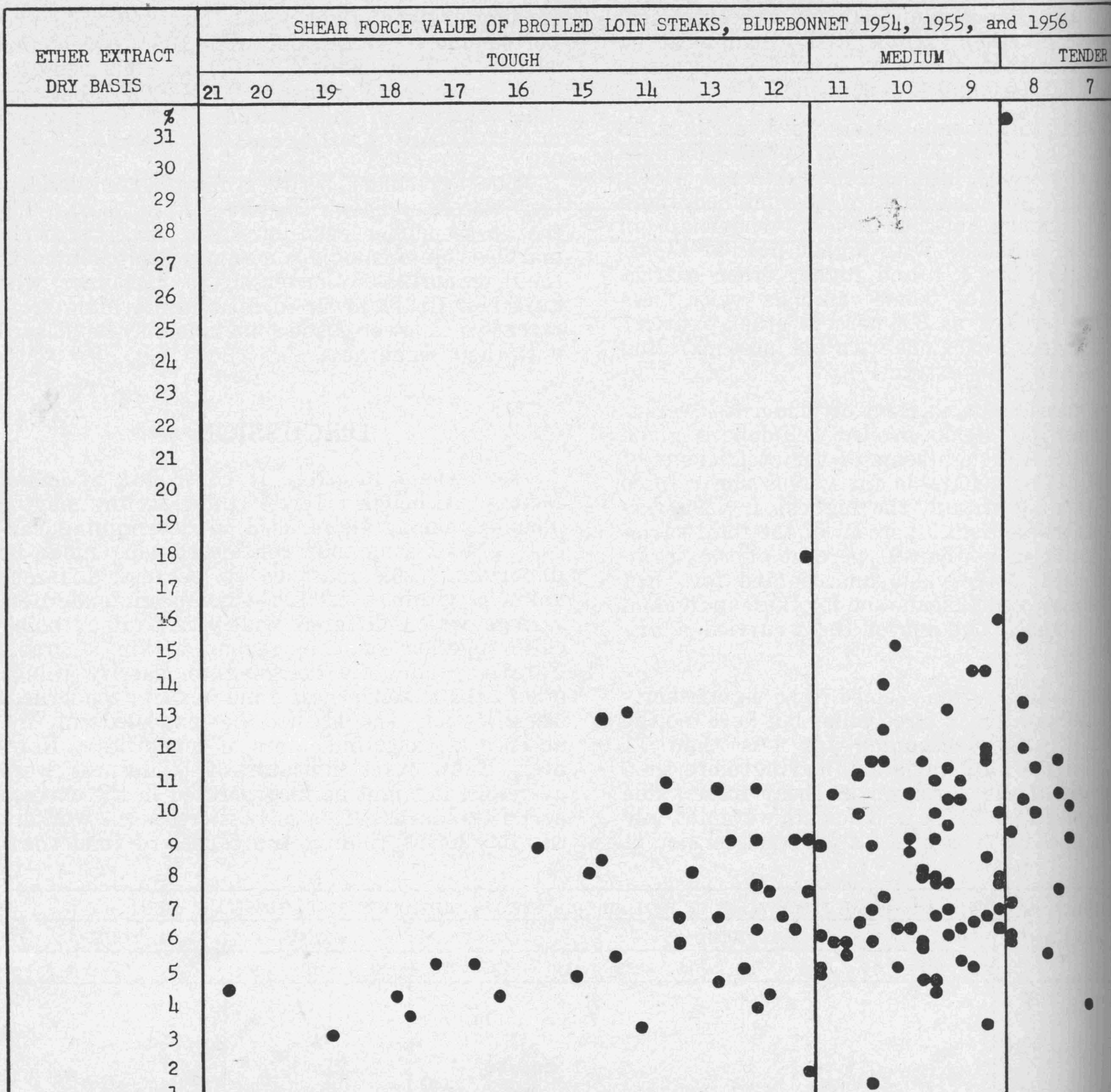

Figure 20. Percentage ether extract of ribeye, a chemical test for marbling, plotted against shear force value of loin ste broiled well-done, 126 Bluebonnet steers, 1954-56. Each dot represents one animal. Statistically, r = —.312, significant at level.

or toughness and developing satisfactory methods of identifying them.

That fatness is related to tenderness has been believed for a long time. However, this relationship apparently is not as direct as was formerly believed. Other factors may have as great or greater importance in determining tenderness or toughness.

Research on more reliable methods of detecting tenderness is urgently needed. One promising lead is that tenderness may be inherited. This phase of the work is receiving considerable attention, Cartwright, Cover and Butler, (1), Cover, Cartwright and Butler, (4). The chemical compounds which cause tenderness or toughne need to be identified. The reactions of these co pounds must be studied under conditions simil to those used in household methods of cooking that tendering or toughening under these cond tions may be understood, Cover and Smith, (Cover, Banister and Kehlenbrink, (6).

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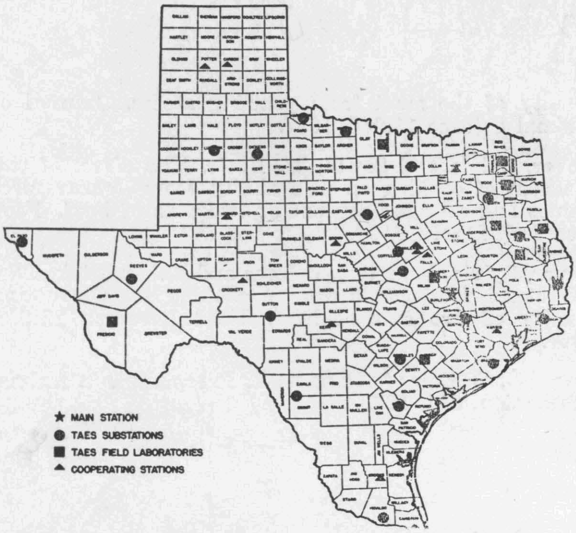

Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

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Plant diseases

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