COMPARATIVE PHYSICAL PROPERTIES OF LEATHER FROM YOUNG BULL HIDES AND STEERHIDES*

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ABSTRACT

The potential economic advantage of raising young bulls for beef may soon result in a significant increase in the proportional numbers of such hides on the market. A detailed study was therefore undertaken to indicate whether any important differences in leather properties might be expected from this new material compared with conventional steerhides. A total of 38 bull sides and 30 steer sides in the crust were evaluated by means of five different test procedures at each of 12 anatomical locations. The bull sides were found to be significantly stronger by every test except the experimental penetrometer test, which showed no real difference. Distribution of strength by location was essentially similar in all cases. Sorting of finished sides revealed a trend towards visible neck wrinkles in the bull hide leather.

Since the experimental hides came from an inbred line of Hereford cattle, the incidence of the vertical fiber defect, which is thought to be genetically controlled, was of special concern. Six hides from bulls and nine from steers were definitely defective and were excluded from the strength comparisons. This is the first known report of the defect in bulls.

—x—x—

INTRODUCTION

Despite the traditional practice of converting (castrating) bulls to steers for better efficiency in beef production, a report by Klosterman *et al.* in 1954 (1) refuted this point and led to a continuing series of confirmatory tests which have still not completely settled the controversy. A number of animal and meat studies were conducted in this country (2–6) and abroad (7, 8) which aroused lively interest among ranchers and feeders (9, 10). Following a USDA report in 1971 (11), the present status of the problem was summarized in an information magazine (12): There are real advantages in bull beef for both the producer and consumer, provided that the animals are under 15 months old at slaughter and that present meat-grading standards are modified.

The work cited above has repeatedly shown that intact bulls from both beef and dairy breeds, when compared with steers castrated by various procedures or with heifers, convert feed more efficiently to liveweight gain and reach marketing weight at an earlier age. Bull carcasses are characterized by larger forequarters, higher yields of lean meat and high-priced cuts, and less fat trim. There is also less fat marbling in the meat and this, while improving its nutritional value, reduces the grade level by present standards, causing it to be discounted in marketing and thus to lose the economic gain from production efficiency. The common connotation of the term "bull" to imply "old and tough" is also a serious marketing handicap. In general, bull meat is equivalent to steer and heifer with respect to flavor, juiciness, and palatability. Therefore, the potential economic advantage of raising young bulls for beef may soon result in increased production of bull hides.

Expression of the secondary sex characteristics is closely related to age. These undesirable changes in bull carcasses and hides occur after 15 months, or beyond the recommended slaughter age. Thus the term "young bull" is more appropriate. Likewise, in referring to the hides from such animals, it is important to realize that they are a new commodity and not as heavy, rough, and scarred as the typical old bull hides of commerce. This study is intended to provide more information on some important properties of tanned young bull hides in anticipation of the likelihood that they may eventually become more common.

Hereford hides were utilized in this study because of a concurrent interest in the vertical fiber defect, which is thought to be limited to this breed and is responsible for extreme weakness in leather (13–15). The sex-related occurrence of this defect has been partially documented by previous studies in this laboratory on hides from known steers (16) and known heifers (17). Presence of the defect in six bull hides of this study completes the cycle of information and indicates that hormonal alterations are not involved. Also, it reinforces the possibility of reducing the incidence of the defect by selective breeding, utilizing the hide biopsy technique (17) to identify and eliminate sire bulls possessing the defect.

EXPERIMENTAL

Hide Source

The plan was to obtain about 50 Hereford steerhides and the same number of young bull hides from cattle of similar genetic and management backgrounds that were slaughtered at comparable weights. This would provide two suitable lots in which the only significant animal difference would be the sex alteration.

An ideal source was located in El Reno, Oklahoma, at a station of the Animal Science Research Division, USDA, where an inbred Hereford line had been developed from four foundation sires over a ten-year period.

When the hides were obtained through a commercial packer in 1969, it was learned that plans had been changed; equal numbers were not available and the slaughter weights were different. Nevertheless, we were able to evaluate 13 bull hides and 30 steerhides for preliminary use while we sought additional bull hides. In 1971 a lot of 25 comparable bull hides was obtained from the same herd to complete this study. Pertinent information is given in Table I. Cured hide weights from 1971 bulls were not recorded but were probably slightly higher than those from the steers.

TABLE I

DATA ON HEREFORD SOURCE OF EXPERIMENTAL HIDES*

	Steers — 1969	Bulls — 1969	Bulls — 1971
Age at Slaughter (months)	14–16	12–14	13–15
Average Live Wt. (lbs.)	902	683	910
Average Hide Wt. (lbs.)	71	60	—
No. of Hides	30	13	25

*Obtained from USDA Animal Science Research Division, El Reno, Oklahoma.

Leather Processing

All the hides were commercially processed by a co-operating tanner into the same type of tropical combat boot leather. This was a common type of production at the time, and it was also chosen to make the leather comparable to that from a previous study of leather properties (16). A complete set of sides was held at the unbuffed crust stage for physical testing, while a number of matching sides were finished into the corrected grain, pigmented side leather for subjective evaluation of sorting characteristics.

The second set of bull hides, obtained in 1971, was necessarily processed in a different plant and tannery lot than the first, which introduced a lot difference as an additional variable. Since the genetic background of the animals was closely similar and the same line of leather was produced, it was considered permissible to pool the data to provide a sufficient number of hides for evaluating the effect of sex alteration. This also provided separate data for evaluating the lot differences. Both of these effects were analyzed statistically by a simultaneous method as explained below.

Physical Testing

The crust sides were divided into 12 test blocks by the standard pattern shown in Figure 1, consisting of three horizontal rows of four blocks each. The shaded

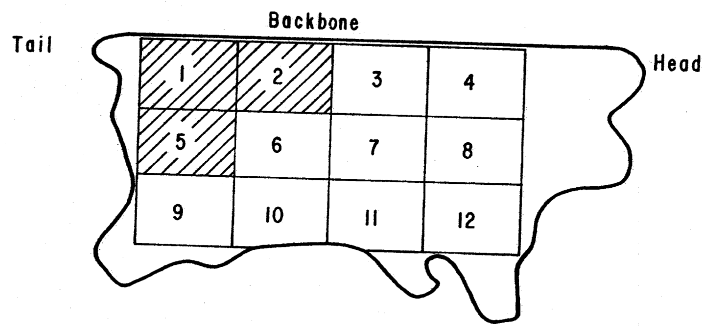

FIGURE 1.—Sampling pattern for cutting test blocks from leather sides, showing three rows and 12 locations used. Shaded blocks, especially Block #1, are usually weaker and are critical for detecting vertical fiber defect.

portion of the diagram (Blocks 1, 2, and 5) is usually the weakest part of the side and is critical for detecting the vertical fiber defect (15, 18–20). Duplicate specimens were removed from each block for performing each of the following tests:

1. Tensile strength and elongation, parallel and perpendicular, according to ASTM-ALCA method D2209-64 (21).

2. Slit tear resistance, parallel and perpendicular, according to ASTM-ALCA method D2212-64 (21).

3. Ball burst (¼ in. ball) strength and extension according to ASTM-ALCA method D2207-64 (21).

4. Grain crack load and extension using the SATRA** Lastometer (¼ in. ball) according to IULCS method I.U.P. 9 (22).

5. Needle penetration resistance using the ERRL penetrometer according to previously published procedure (23).

6. Fiber orientation to distinguish between the normal structure and the vertical fiber defect, using a low-power stereomicroscope to examine the cut edges of a two-inch disk of leather as described previously (16).

All specimens were conditioned and tested at 23°C. and 50 percent relative humidity. Results for the five types of strength tests (Items 1 to 5 above) were calculated on a thickness basis, while those for the extension tests (Items 1, 3, and 4) were not. The data from steer and bull sides were each separated into normal and defective (vertical fiber) groups and for each group the side average and location (block) average was calculated for each test.

Statistical Analysis

The data were first analyzed using a conventional split-plot analysis of variance to evaluate the differences due to sex condition, hide location, and sex-loca-

**Reference to brand or firm name does not constitute endorsement by the U. S. Department of Agriculture over others of a similar nature not mentioned.

tion interaction. Then it was realized that this did not take into account the lot differences described above under "Leather Processing." For this reason a modified analysis employing orthogonal contrasts (24, p. 329) was applied, which compared separately the variations between bull hides and steerhides and between the two lots of bull hides, to show the significance of each of these critical variables.

RESULTS AND DISCUSSION

Sorting Characteristics

From the first two lots of bull and steer sides obtained in 1969 (see Table I), six from each group were randomly chosen for finishing into black corrected grain to permit comparison of general quality. The bull sides were not as smooth as the steers; they consistently showed traces of neck wrinkles and more frequent scars from scratches. Also, the bull sides had a somewhat coarser break and less firmness and roundness than the steer sides. Overall the steer sides were rated superior to the bull sides.

In the second lot of bull sides obtained in 1971, a complete set of 25 sides was finished for evaluation. Even though these bulls were slightly older and heavier than the previous ones, the leather resembled the steer sides very closely. There were only a few cases of visible neck wrinkles and, in general, these bull sides were hardly distinguishable from the steer sides or from the tanner's normal production. Thus it might be concluded that most of the differences observed could be attributed to a lot or chance difference. The secondary sex characteristic of prominent neck wrinkles is apparently the only feature that is likely to impair the quality of leather from young bull hides.

Physical Properties

As mentioned previously, physical test comparisons were made on the crust sides by subdividing the bull and steer groups into normal and defective fiber categories. Table II summarizes the average values determined for the 53 sides with normal fiber structure. Side averages for each type are listed in one column alongside of corresponding values for the area (Blocks 1, 2, and 5) most suspected of weakness, as indicated in Figure 1. The tests listed on the first seven lines are considered to measure strength, while those on the last four reflect stretch properties. Comparison of values for the two sex types reveals that the data for bull sides are consistently higher than those for the steers, with the single exception of ball burst extension. In most cases, these differences are so small as to require statistical confirmation of their significance.

Table III gives similar data for the 15 sides that were found to be defective by microscopic examination. In this series the results were not so consistently favorable to the bull sides, but the significant reductions from normal levels are very evident, especially among the strength tests.

TABLE II

AVERAGE TEST VALUES FOR 32 BULL SIDES AND 21 STEER SIDES WITH NORMAL FIBER STRUCTURE

Physical Tests	Units	Bull Sides		Steer Sides	
		Side Avg.*	1-2-5 Avg.†	Side Avg.*	1-2-5 Avg.†
Tensile, parallel	lbs./in.^{2}	2947	2272	2594	2021
Tensile, perpendicular	lbs./in.^{2}	2342	2091	2084	1672
Slit Tear, parallel	lbs./in.	555	445	525	390
Slit Tear, perpendicular	lbs./in.	606	471	559	403
Ball Burst	lbs./in.	1878	1661	1831	1617
Penetrometer	lbs./in.	133	129	129	122
Grain Crack Load	kg./cm.	177	141	172	108
Grain Crack Extension	mm.	9.32	9.06	8.01	7.50
Ball Burst Extension	in.	0.41	0.44	0.42	0.46
Tensile Elongation, parallel	%	45	53	42	51
Tensile Elongation, perpendicular	%	59	57	54	54

*Average of all 12 sampling locations shown in Figure 1.
†Average of sample locations 1, 2, and 5 shown in Figure 1.

TABLE III

AVERAGE TEST VALUES FOR SIX BULL SIDES AND NINE STEER SIDES WITH VERTICAL FIBER DEFECT

Physical Tests	Units	Bull Sides		Steer Sides	
		Side Avg.*	1-2-5 Avg.†	Side Avg.*	1-2-5 Avg.†
Tensile, parallel	lbs./in.^{2}	2193	1624	1767	1029
Tensile, perpendicular	lbs./in.^{2}	1762	1580	1435	872
Slit Tear, parallel	lbs./in.	488	386	421	269
Slit Tear, perpendicular	lbs./in.	504	385	428	259
Ball Burst	lbs./in.	1497	1140	1508	903
Penetrometer	lbs./in.	119	109	119	80
Grain Crack Load	kg./cm.	109	96	123	53
Grain Crack Extension	mm.	7.91	8.16	7.26	6.89
Ball Burst Extension	in.	0.39	0.40	0.43	0.51
Tensile Elongation, parallel	%	44	45	47	60
Tensile Elongation, perpendicular	%	54	49	60	61

*Average of all 12 sampling locations shown in Figure 1.
†Average of sample locations 1, 2, and 5 shown in Figure 1.

Statistical Interpretation

The primary objective was to indicate whether leather made from young bull hides differed significantly in physical properties from similar leather made from equivalent steerhides. The study was complicated, as explained above, by a secondary need to evaluate lot differences. For these purposes, the orthogonal contrast analysis was applied to the data from the 53 normal sides that were

TABLE IV

ANALYSIS OF VARIANCE BY ORTHOGONAL CONTRASTS
TENSILE STRENGTH, PARALLEL, OF 53 NORMAL SIDES*

Sources of Variation	Degrees of Freedom	Sums of Squares	Mean Squares	F Values
Among Sides	50	123,342,985.3	2,466,859.7	14.6**
Locations	11	178,984,708.8	16,271,337.2	96.5**
Lot x Location	22	26,686,398.8	1,213,018.1	7.2**
Contrast-1†	1	19,347,500.9	19,347,500.9	114.7**
Contrast-2‡	1	430,395.8	430,395.8	2.6ns
Residual	550	92,776,939.9	168,685.3	

*Data on crust leather with normal fiber structure from 32 bull sides and 21 steer sides, each tested at 12 standard locations.

**Indicates highly significant difference ($P < .01$); ns means not significant.

†Contrast-1 measures the sex effect or difference between all bull sides and steer sides.

‡Contrast-2 measures the lot effect or difference between the two tannery lots of comparable bull sides.

summarized in Table II. A sample analysis for tensile strength (parallel) data is shown in Table IV. Here it can be seen that the differences among sides, among locations, and the lot-location interactions are all highly significant, as would be expected. The difference between bull and steer sides, measured by contrast-1, is also shown to be highly significant, but the lot difference, measured by contrast-2, is not significant in this case.

The statistical summary for the entire set of measurements on the 53 normal sides is given in Table V. It was not considered necessary to analyze the data from the 15 defective sides. From the "F" values in the first three columns of figures, it is evident that the variations among sides, among locations, and from the lot-location interactions were all highly significant (one percent level) for all tests. The all-important effects of sex alteration, or bull-steer comparisons, are shown in the fourth column of figures. Results for every test applied except the experimental penetrometer test (23) show a highly significant difference. Reference to Table II shows that all of these values except the ball burst extension favor the bull sides. So it may be concluded that, based on this test, leather

TABLE V

STATISTICAL F VALUES FROM COMPARISON OF PHYSICAL TESTS
32 BULL SIDES *VS.* 21 STEER SIDES†

Physical Tests‡	Sources of Variation				
	Sides	Locations	L x L	Sex Difference	Lot Difference
Tensile, parallel	14.6**	96.5**	7.2**	114.7**	2.6 ns
Tensile, perpendicular	15.4**	42.4**	12.5**	113.9**	1.8 ns
Slit Tear, parallel	10.4**	98.2**	6.5**	35.4**	3.7 ns
Slit Tear, perpendicular	13.5**	146.7**	8.1**	89.4**	25.9**
Ball Burst	9.6**	36.2**	6.9**	7.8**	4.0*
Penetrometer	13.7**	29.0**	4.6**	2.0 ns	84.9**
Grain Crack Load	14.2**	72.5**	13.9**	8.8**	84.5**
Grain Crack Extension	9.2**	30.4**	11.2**	374.3**	116.0**
Ball Burst Extension	6.6**	40.5**	6.3**	8.9**	68.1**
Tensile Elongation, parallel	6.0**	149.3**	16.7**	98.9**	72.0**
Tensile Elongation, perpendicular	6.0**	55.6**	13.3**	126.0**	100.3**

†See Table IV for fuller explanation from a single analysis.
‡See Table II for test units and average test values.
*Indicates significant difference ($P<.05$) ; ns means not significant.
**Indicates highly significant difference ($P<.01$).

made from young bull hides is probably superior in physical properties to similar leather made from comparable steerhides.

The results in the last column indicate that seven of the 11 tests detected a highly significant (one percent level) difference between the leathers from the two tannery lots of bull hides. One other test showed a significant (five percent level) difference, while differences in the remaining three comparisons were not significant. These observations on the significance of lot differences in strength properties complement the work of Tancous (25), who reported highly significant lot differences in break, temper, compression, and elastic properties.

Strength Distribution

A system devised by Maeser (26), for plotting leather strength values by anatomical location on the side, showed reproducible patterns of variation for all types of bovine leather. Vos and van Vlimmeren (27) added additional data and showed summary plots for various test procedures which further confirmed the consistency of these patterns. Average values for normal sides from the 12 locations shown in Figure 1 were plotted in a similar manner, mainly to indicate any important differences between bull and steer leather but also to examine their agreement with established trends. Our data were not quite as extensive because they represented a total of only 53 hides; nevertheless, the results are useful and pertinent to this study.

Figure 2 shows the distribution plots for tensile strength in the direction parallel to the backbone. Side averages for the two types of leather are shown

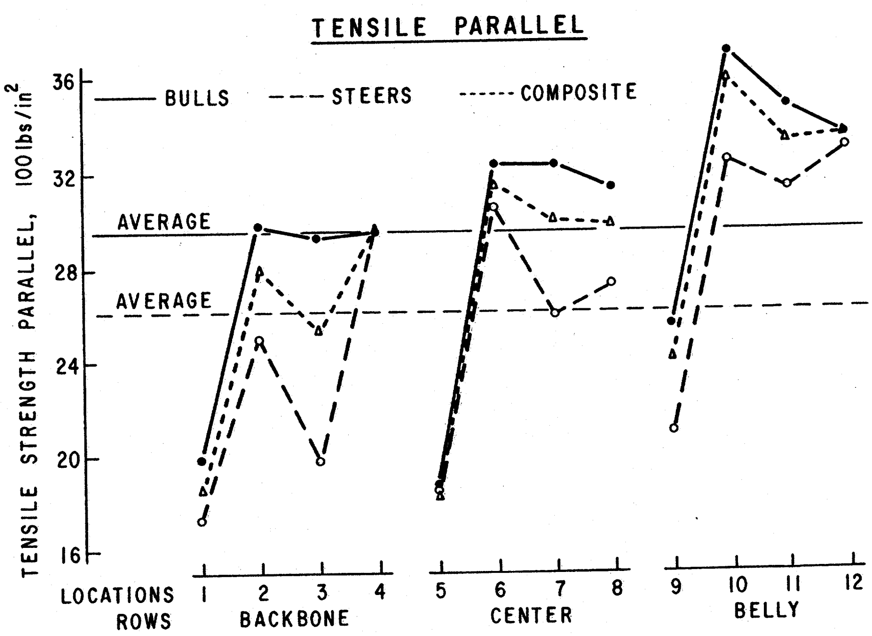

FIGURE 2.—Distribution of tensile strength according to locations and rows shown in Figure 1. Data points are average values for 21 steer sides and 32 bull sides with normal fiber structure. Dotted lines show composite values for all 53 sides. Horizontal lines show side averages for the two groups.

as horizontal lines. In order to minimize the apparent discrepancies between the bull and steer curves due to the small numbers represented, composite curves for the whole set are shown by dotted lines. These values are the least-square means derived from the analysis of variance and should be more generally representative. When it is noted that locations 1-5-9 are at the rear while 4-8-12 are at the front of three horizontal rows, there is a general trend of gradually increasing strength from backbone to belly and from rear to front. The shapes of the curves for bulls and steers are not significantly different although the magnitudes of the bull values are consistently higher. The same observations also characterize the data from the 15 defective sides not shown but, of course, their magnitudes are considerably lower than those from the normals. Compared with the more representative curves mentioned above (27), the plot for the backbone row showed good agreement but the other two did not. Front locations of our center and belly strips should have been much weaker for agreement. Tensile strength in the direction perpendicular to the backbone showed similar trends but had lower values than the parallel. Percent elongation tended to decrease from rear to front, especially in the two upper rows, but there was much irregularity in the distribution curves.

Figure 3 shows similar plots for slit tear resistance in the direction parallel to the backbone. Close agreement within the pairs of curves shows that there is

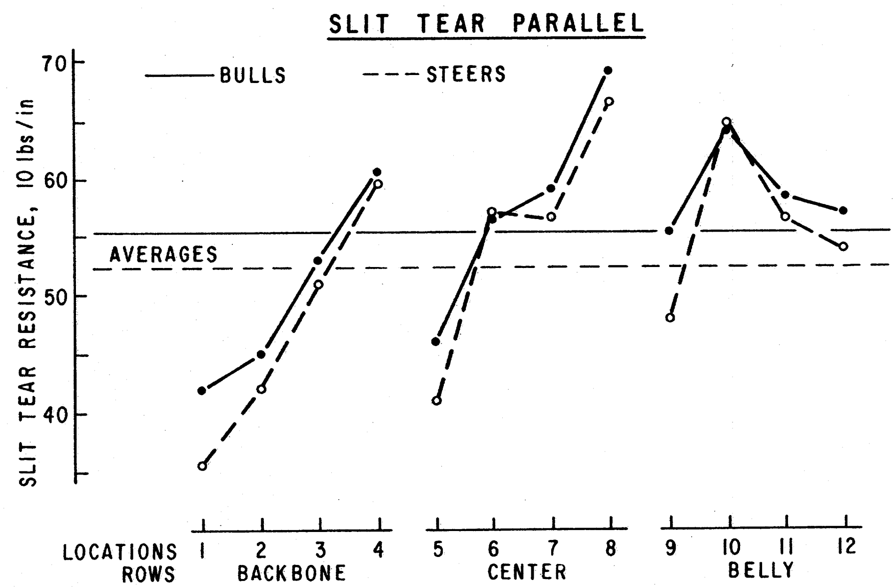

FIGURE 3.—Distribution of slit tear resistance according to locations and rows shown in Figure 1. Data points are average values for 21 steer sides and 32 bull sides with normal fiber structure. Horizontal lines show side averages for the two groups.

no essential difference between the two types of leather in this respect and no need for composite data. There is a sharp, continuous increase in strength from rear to front in the two upper rows but a smaller range among belly locations. The closest comparison with other data (27) involves the tongue tear strength; with these data there is only partial agreement. Trends for slit tear perpendicular were similar to those in the parallel direction but, unlike the tensile test, the slit tear perpendicular values were higher.

Figure 4 shows similar results for bursting strength by the ball burst test. Again there is close agreement in the shapes of the curves and no indication that the two types of leather are essentially different. However, there is one important departure from the trends seen in the previous figures. In the belly row the front end (Location 12) is much weaker than average. Since this same trend was shown for the large set of tensile data (27), perhaps this is more nearly representative of the true situation with strength tests.

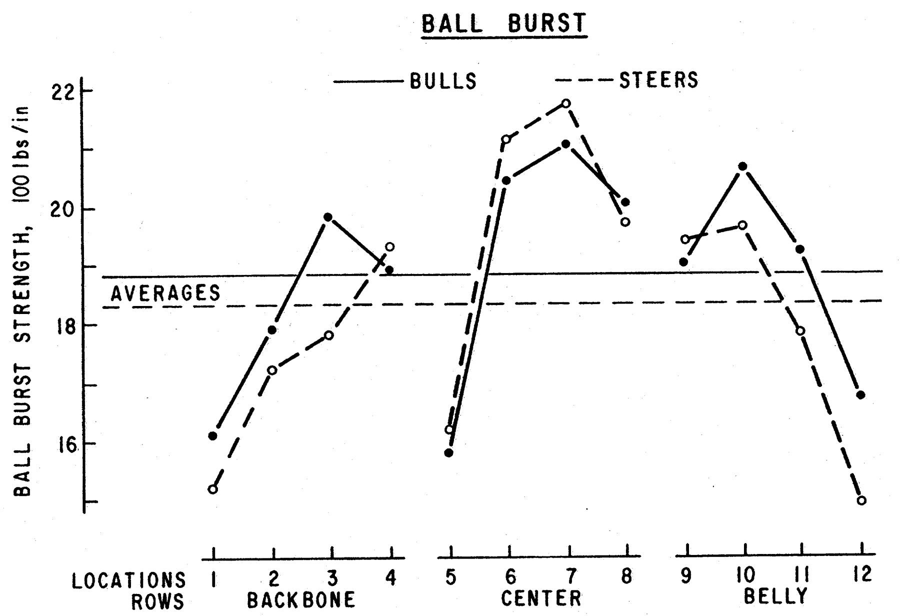

FIGURE 4.—Distribution of ball burst strength according to locations and rows shown in Figure 1. Data points are average values for 21 steer sides and 32 bull sides with normal fiber structure. Horizontal lines show side averages for the two groups.

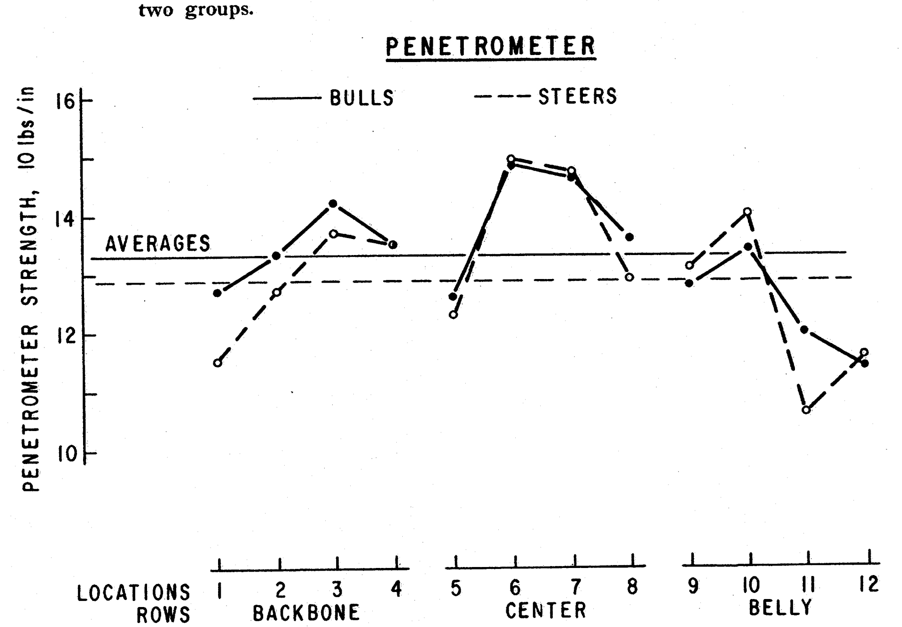

FIGURE 5.—Distribution of penetrometer strength (resistance to needle penetration) according to locations and rows shown in Figure 1. Data points are average values for 21 steer sides and 32 bull sides with normal fiber structure. Horizontal lines show side averages for the two groups.

The curves in Figure 5 for penetrometer strength are closely similar in all respects to those for ball burst in Figure 4, except that the penetrometer test showed a narrower range of variation with location. The close correlation between these two tests when applied to dry leather has been reported previously (23), suggesting that the nondestructive penetrometer deserves further trial as a practical sorting device.

Figure 6 shows the distribution of grain crack (Lastometer) load values expressed on a thickness basis. Again there appears to be no essential difference between the two types of leather. In each of the three rows there is a pronounced

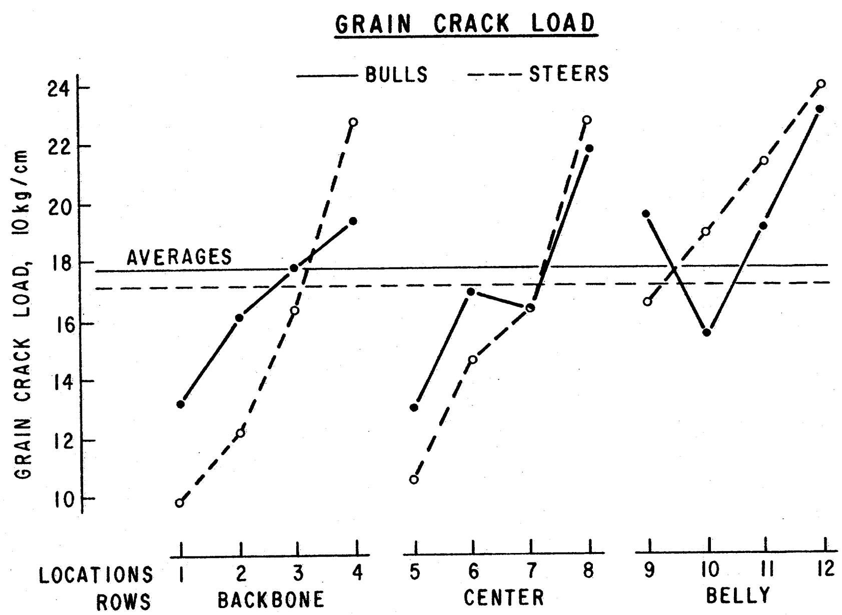

FIGURE 6.—Distribution of grain crack load according to locations and rows shown in Figure 1. Data points are average values for 21 steer sides and 32 bull sides with normal fiber structure. Horizontal lines show side averages for the two groups.

increase in grain strength from rear to front locations, similar to trends shown elsewhere for this and the Mullen test (27), and a gradual increase from backbone to belly. The curves for extension at grain crack, as shown in Figure 7, indicate more variation with location than usual (27). Since these particular curves are somewhat erratic, the composite curves (dotted lines) are also shown, which are more typical, except for Location 12. There appears to be more difference between the two types of leather by this test than by any of the others, and the bull leather is obviously superior.

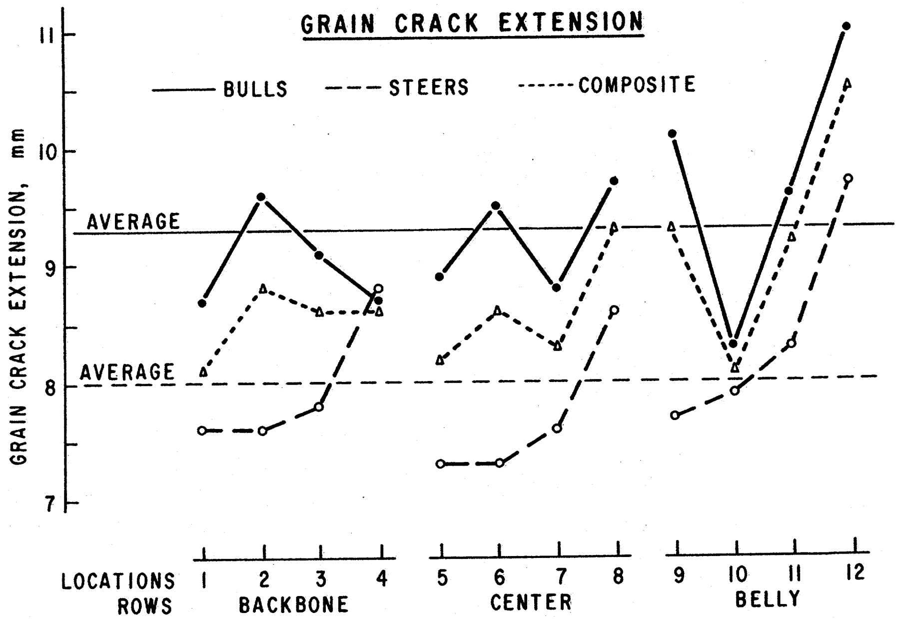

FIGURE 7.—Distribution of grain crack extension according to locations and rows shown in Figure 1. Data points are average values for 21 steer sides and 32 bull sides with normal fiber structure. Dotted lines show composite values for all 53 sides. Horizontal lines show side averages for the two groups.

Incidence of Vertical Fiber Defect

As mentioned in the Experimental section, the herd source of these Hereford hides is an inbred line derived mainly from four foundation sires. Incomplete genealogies of the animals involved, covering at least four generations, were related to fiber structure abnormality in an effort to pinpoint the genetic source of observed cases of defect. Owing to frequent intermixing of the breeding lines, it is not possible to deduce accurate conclusions, but the following incidence levels are of much interest:

Sire A descendants: 30 percent defective (6/20)

Sire B descendants: 35 percent defective (6/17)

Sire C descendants: nine percent defective (2/23)

Sire D descendants: 13 percent defective (1/8)

The total incidence of 22 percent (15 of 68) with vertical fiber structure is well above expected levels and demonstrates an undesirable aspect of inbreeding. Sires A and B appear to be the likely sources of defect in this herd. Furthermore, an additional 34 percent (23 of 68) of the hides had an "intermediate" type of abnormal fiber structure (17), in one or more locations, that is poorly understood but is responsible for less extreme weakness than vertical structure. Six

(16 percent) of the bull hides and nine (30 percent) of the steerhides had the vertical fiber defect.

CONCLUSIONS

This study indicates that the strength of side upper leather made from young bull hides was consistently superior to that of comparable steerhide leather as measured by four standard tests. Sorting characteristics of corrected grain finished leathers were fairly similar, except for a tendency towards prominent neck wrinkles in the bull sides. Only one type of leather was evaluated and there were significant lot differences in many of the properties.

The final conclusion is that hides from young bulls raised for beef should be just as satisfactory, at least for corrected grain leather, as the common steer and heifer classes.

The vertical fiber defect was found in 22 percent of the hides, including both steers and bulls. Such a high incidence from an inbred Hereford line supports previous evidence that the defect is genetically controlled.

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