Because tenderness is such an important component of the eating satisfaction of meat, a reliable method of detecting it is greatly needed. Such a method ought to be suitable for detecting tenderness or toughness in the steak before it is cooked, in the wholesale cut, in the carcass, and in the live animal. Until the chemical and physical causes of tenderness or toughness are understood completely, our chances of detecting or controlling it adequately seem remote. Therefore, it is important to begin systemic efforts to tabulate the various kinds and degrees of tenderness impressions observed under standardized conditions. If this is done well, then perhaps we may be able to associate these observations with pertinent chemical or physical changes or with differences in management or breeding.

In the past, members of a judging panel have been asked to record only one score for tenderness of beef. When such scoring is done on only one cut cooked by only one standardized method, scoring for tenderness is relatively simple. But when judges are presented with meat from different cuts cooked in several different ways, they must relate a variety of sensations to tenderness. Then, scoring may be exceedingly complex and the scores difficult to interpret. A few illustrations may make this point clear. Judges' scores for tenderness of rare steaks may be influenced by their softness. Swallowing these soft juicy morsels may take place before the tenderness of either the muscle fibers or the connective tissue has been assessed. But coarse connective tissue will be very evident in soft juicy morsels from rare bottom round steaks if they are chewed thoroughly. In very well-done braised steaks the meat may seem hard at first, but in bottom round it may break up readily after a few chews. In this case the muscle fibers may crumble easily into tiny fragments and little or no connective tissue may be felt. With braised loin steaks, however, the meat may be stringy because little connective tissue is present and the muscle fibers are only slightly friable. Such differences in tenderness characteristics are difficult for a judge to report in a single score for tenderness. Yet if chemical causes of tenderness or toughness are to be investigated, precise descriptions of tenderness changes during cooking are imperative. It is especially important to separate toughness caused by connective tissue from that caused by muscle fibers. Breaking tenderness down into a component from muscle fibers and one from connective tissue was attempted by Lehman (2) as long ago as 1907.

Various mechanical devices for measuring tenderness objectively have been constructed. Mr. Schultz did a very good job of listing and describing them for your meeting last year (3). But no one of these devices measures all aspects of tenderness.

It seemed possible that intelligent personnel might be trained to discriminate among the different tenderness sensations and to give information which it is not yet possible to obtain from mechanical devices. The description of two such attempts is presented in this paper.
First attempt. Separation of tenderness components was attempted first with the 1955 Bluebonnet steers, using separate scores for muscle fibers and for connective tissue (1). But in that study a connective tissue score was reported only when obvious connective tissue was identified by sight or detected during mastication. Thus, not all samples received a score for connective tissue. A score for muscle fibers was obtained for all samples. It included not only the tenderness of the muscle fibers but also the tenderness of any connective tissue which seemed inseparable from them. The data collected that year included steaks from longissimus dorsi in loin and biceps femoris in bottom round. Both muscles were cooked by broiling to internal temperatures of 61°C. (rare) and 80°C. (well-done) and by braising to internal temperatures of 85°C. (medium) and of 100°C. plus holding there for 25 minutes. Thus, there was an opportunity for wide differences in tenderness. The results of these tests are shown in Table 1.

The data on connective tissue suggest that differences were detected. Because 52 pieces of meat from each method of cooking had been presented to each of four judges, there were 208 opportunities to report connective tissue. For longissimus dorsi there were fewer than 20 such reports within any of the 4 conditions of cooking; while for biceps femoris there were more than 180 (Table 1). Thus, in only an occasional loin steak did an occasional judge find identifiable connective tissue and even then it was relatively tender. In bottom round steaks however, most judges found identifiable connective tissue in most of the steaks and it was tougher than that found in the loin. The different conditions of cooking did not seem to affect greatly either the tenderness of the connective tissue or the frequency of reporting, except when the steaks were braised very well-done (100°C. + 25 minutes). In that case, the connective tissue in both cuts seemed to be somewhat more tender and the number of reports were somewhat fewer than with the other three conditions of cooking. Braising very well-done employed those cooking conditions usually considered favorable for changing collagen into gelatin and thus tenderizing the connective tissue.

A tenderness score for "muscle fibers" was obtained on all samples. In both cuts, the fibers were significantly more tender broiled rare than well-done. When longissimus was braised to the two internal temperatures no significant difference was observed, but biceps femoris was significantly more tender braised very well-done than to 85°C.

Juiciness scores were highest when the cuts were broiled to the lower internal temperature and were lowest when the cuts were braised to the higher internal temperature.

The shear force values indicated that loin steaks were most tender when broiled rare, but that bottom round steaks were most tender when braised very well-done.

Second attempt. A second attempt at measuring various aspects of tenderness was made with the 1956 Bluebonnet steers. There were 55 steers and steaks from loin and bottom round were cooked in the same ways as before. Tenderness was divided into scores for softness, friability and tenderness of connective tissue. The score card used in that study is shown in Table 2. The judges were given a preliminary training period. They were told that
softness should be rated according to the sensations from tongue and cheek and by the ease with which the teeth sink into the meat at the first bite. Friability should be determined on how easily crumbling of the muscle fibers takes place. Tenderness of connective tissue should be judged in three ways: none is felt; some is felt or heard during chewing, but all of it disappears during chewing; some connective tissue is left in the mouth even after thorough chewing and must be either gulped or discarded. This latter type of connective tissue is likely to be called "gristle" by homemakers.

TAES, Department of Home Economics

Table 1. Juiciness and Tenderness Data for 1955 Steers, averages of two steaks from each of 26 animals

<table>
<thead>
<tr>
<th>Methods of cooking</th>
<th>Cuts</th>
<th>Final cooking temp.</th>
<th>Juiciness scores</th>
<th>Shear force values</th>
<th>Tenderness scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Muscle fibers&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Broiled</td>
<td>Loin</td>
<td>61°C.</td>
<td>8.7</td>
<td>7.4</td>
<td>7.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80°C.</td>
<td>5.3</td>
<td>9.8</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(c)</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td></td>
<td>B.R.</td>
<td>61°C.</td>
<td>9.2</td>
<td>9.7</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80°C.</td>
<td>5.3</td>
<td>9.2</td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(c)</td>
<td>***</td>
<td>n.s.</td>
<td>***</td>
</tr>
<tr>
<td>Braised</td>
<td>Loin</td>
<td>85°C.</td>
<td>5.9</td>
<td>9.4</td>
<td>5.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100°C.+</td>
<td>3.3</td>
<td>9.3</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(c)</td>
<td>***</td>
<td>n.s.</td>
<td>n.s.</td>
</tr>
<tr>
<td></td>
<td>B.R.</td>
<td>85°C.</td>
<td>5.3</td>
<td>9.4</td>
<td>5.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100°C.+</td>
<td>3.4</td>
<td>6.4</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(c)</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
</tbody>
</table>

(a) These scores include also any connective tissue which seemed indistinguishable from the muscle fibers.

(b) Total number of possible judgments was 208. Number of scores on which average is based is given in parentheses.

(c) n.s., *** indicate significance above 5% level, and at 0.1% level respectively, determined from analyses of variance.

The broiled steaks of both cuts, when rare, were scored very juicy, soft, and moderately friable, but when well-done they were scored medium in juiciness, medium in softness and friable. Thus, as doneness increased these broiled steaks became less juicy and less soft but more friable. The
connective tissue in the loin was so tender that there was little or no room for improvement with doneness, but in bottom round, the rare broiled steaks had considerable firm connective tissue which tendered significantly as doneness increased. Shear force values increased with increased doneness in broiled loin steaks—the meat got tougher—but broiled bottom round steaks showed no significant change with doneness.

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Table 2. Adjectives Used in Scoring Meat and Associated Weighting (1956 data)

<table>
<thead>
<tr>
<th>Weighting of adjectives</th>
<th>Adjective used in scoring</th>
<th>Tenderness of residual connective tissue</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Juiciness</td>
<td>Softness</td>
</tr>
<tr>
<td>10</td>
<td>Extremely juicy</td>
<td>Extremely soft</td>
</tr>
<tr>
<td>9</td>
<td>Very juicy</td>
<td>Very soft</td>
</tr>
<tr>
<td>8</td>
<td>Juicy</td>
<td>Soft</td>
</tr>
<tr>
<td>6</td>
<td>Neither juicy nor dry</td>
<td>Neither hard nor soft</td>
</tr>
<tr>
<td>5</td>
<td>Dry</td>
<td>Hard</td>
</tr>
<tr>
<td>4</td>
<td>Very dry</td>
<td>Very hard</td>
</tr>
<tr>
<td>3</td>
<td>Too dry to swallow</td>
<td>Too hard to chew</td>
</tr>
</tbody>
</table>

The braised steaks of both cuts became less juicy as doneness increased. In the loin steaks, which were braised, doneness did not seem to
affect scores for softness, friability, and tenderness of connective tissue, but in bottom round steaks the ones which were braised longer were softer, more friable and the connective tissue was more tender. Shear force values of braised steaks increased with doneness in loin (the meat got tougher) but decreased with doneness in bottom round (the meat got more tender).

Thus far our research has confirmed some of the old ideas about connective tissue: it is present in larger amounts and is tougher in bottom round than in loin; and, where it was tough and was present in considerable amount, its tenderness increased markedly with increases in internal steak temperature. But, we do not understand the difference in the chemical make up of the connective tissue in loin and bottom round. Does the heavy tough connective tissue of bottom round differ qualitatively as well as quantitatively from that in loin? Are there more elastic fibers in one cut than in the other? Does one cut have denser collagen than the other? Good correlation of judge's score for connective tissue with a chemical constituent of connective tissue would be desirable.

That our former theories on tenderness of muscle proteins are not adequate is indicated by our research. The familiar principle of meat cookery, "High heat toughens protein", seemed to apply to the fiber proteins in longissimus dorsi muscle but not to those in biceps femoris. This contrast in tenderness of the muscle fibers in the two muscles opens the way to considerable new research. A new approach to inherent chemical differences may be possible. The heritability of the animal may prove to be related not only to tenderness as tested by taste panel but also to tenderness as determined by chemical methods.

**Literature Cited**


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MR. COLE: Well, I was right, I think. I believe you will all agree with me that certainly Miss Cover is doing a fine job and, as she said or as that oldster said, we are continually finding new things that are not right, and we have a real job cut out for us in the future.
Now Vern says that we have a few minutes, although my watch says it is after time, but I think we got a little late start, and I should like to open the floor to questions.

I believe that both of these last two talks are available, that they are in printed form and are being distributed. incidentally, some of you saw Mr. Warwick leave. He had to catch a plane, and if any questions are directed to him, we will turn them over either to Mr. Wythe or Miss Cover to answer.

Do you have any questions?

MR. SULZBACHER: I should just like to say in response to Miss Cover's opening remarks that our composition of quality investigation group, which is under the direction of Clifton Swift, whom you all heard yesterday morning, has been working on the differences in composition of different muscles, and we are coming up with rather remarkable differences in the proteins of different muscles. Some of the early results of this work were reported at this year's AMIF meeting, and we look for a good many more of them to be reported as time goes on.

MR. COLE: Thank you, Mr. Sulzbacher. Are there other questions or comments?

MR. BRATZLER: I hesitate to get up. I am not doubting those correlations, they are excellent, but before you folks get too hepped on the bone measurement and length you should ask Leon if he keeps the whole weights constant on the carcasses. I have a sneaking suspicion from a recent oral examination that the significance went down when the weight was held constant. How about that, Leon?

MR. ORME: I don't know. I left the pieces home.

MR. COLE: That boy is going to Tennessee.

MR. ORME: We did measurements on the cannon bone only on 31 Hereford and Angus cattle of comparable age, comparable conformation, and breeding. Our weights and lengths probably were comparable with the correlations that were given here in relation to weights of wholesale cuts and also to ribeye area, and I think -- well, I will go along with Professor Bratzler. I think when you run standard coefficients on them and hold the weights constant they decrease quite rapidly.

MR. WYTHE: Did you run any weight-length ratio correlations?

MR. ORME: No, we did not.

MR. WYTHE: That might partially answer that.

MR. ORME: We combined two of them, the weight and length of the two best ones. We did some circumference measurements and some radius measurements and they were not too good at all, on metacarpals and metatarsus. Maybe Mr. Pearson can remember more of the data on the correlations.
MR. PEARSON: I did not mean to get into this, Leon. I would just as soon you left me out because I left my memory at home, too. From memory, I think that our correlations were lower than yours, and we did not combine the length and width measurements, but working with both the front and rear cannon bones from both legs and also working with x-ray -- I think x-ray was the thing -- we worked with x-ray at the lumbar region, and there was very good correlation between different measurements taken from the lumbar region and the x-rays and the weights of cannon bones in relationship to actual leanness, and physical separation of the 9th, 10th and 11th rib section was quite low.

I should say that is when you put them on a percentage basis. If you put them on a weight, such as your figures are on, they look good. If you don't take weight out they look pretty good, but if you take weight out and put them on a percentage basis they look quite low.

MR. MENKEL: Our correlation looked very much like that until we removed the weight effect and then the correlation decreased to almost either being just barely significant or to no significance. However, I do want to say that our boning measurements were actual measurements on the live animals, that is, we measured the length, the height, and everything. We did not attempt to take the bones from the slaughtered animals and to make any measurements on the bones per se as you indicated. That maybe one of the reasons our correlations are slightly lower than yours to begin with.

MR. ORME: We compare the circumference of the live animal versus the circumference of the clean bones and the correlation is not too good.

MR. WYTHE: I might add here that a few correlations were run on the Brahma cross bred cattle and it seems from the Brahma blood you get in there you can always tell how long the cannon bone is.

MR. HECK: I was wondering if they had any way of measuring the amount of calcium in the bones which might increase the weight of the bones. It could be an indication of bone washed out of calcium and that would influence the weight, would it not?

MR. COLE: I believe you said something about specific gravity a while ago.

MR. WYTHE: We have made no measurement of the actual viscous bone. I think that needs to be looked into.

MR. KING: I would like to ask, did you do specific gravity or was it all live?

MR. ORME: It was all live animal measurements. What we tried to do in this study is we tried to correlate the various live animal measurements with the carcass. We did not do specific gravity on bone. We did some breaking strengths on bones, trying to relate breaking strengths to tenderness.
MR. KING: I should like to add that we certainly are not presenting this as the solution by any means with that small number of cattle. The fantastic results that are presented in the literature by our New Zealand workers and our English workers show some promise. We have attempted to duplicate them and we cannot, or we have not, but I think it is another tool that might be pursued or used in trying to discover some objective measure that might be used in evaluating the live animal without having to destroy it to determine whether it is worth anything or not.

MR. PEARSON: I should like to ask one question. In our work we have read the claims in the New Zealand literature of Hertzel and in the Australian literature of Mr. McMeakin; yet we have never found data in detail that justifies their statements. I don't know whether you have found anything in more detail. We have read some popular statements from them but nothing that justified it from a scientific standpoint.

MR. WYTRE: I have had some correspondence from Miss Walker and I understand that Mr. McMeakin was in Europe and I was not able to get in touch with him personally. However, I heartily agree with the statement that you made.

MR. COLE: I should like to ask somebody from Texas what would have happened if you had used total bone as compared with one bone correlated with the same cuts.

MR. WYTRE: The same picture, the weight of--

MR. COLE: No, I mean when you do a lean-fat bone separation, if you just correlate total separable bone.

MR. KING: We didn't do that. I should like to answer your question, too. We had Miss Walker on our campus and we could not get anything out of her either.

MR. WELLINGTON: Just as a wee bit of defence of McMeakin and his group, we corresponded with him relative to statements which he was quoted as making in the Shorthorn World on this problem of bone and its relationship to muscle weights and he explained that he really did not author that article, that it was rather lifted out, and if you are referring to the Shorthorn World report he really does not take credit for what is written in it.

MR. KING: I am referring to direct questions asked of Miss Walker, George.

MR. WYTRE: Isn't Mr. Birmingham from New Zealand? Maybe he can answer the question.

MR. DEATHERAGE: Well, I would turn back to Miss Cover. She apologized for the bit that she has done, but she is the only one as far as I am concerned who has ever done any work on meat cookery that is
scientifically solid and I really think it is too bad that she could not tell us a little more. Particularly it is very significant, I think, that she has clearly shown these differences in muscle that we have known do exist. I don't know whether she has given anybody else any ideas but she has given me enough ideas to keep me busy for five years if I can get some hands to help me.

MR. COLE: Miss Cover, that is your objective, isn't it?

MISS COVER: Yes. We have plenty to keep us busy too. All of you can get into it.

MR. COLE: I think that is one thing we all realize from these conventions.

MR. R. L. HINER: We were quite actively engaged in the use of the objective method for determining tenderness of live animals. We approached it from both the chemical and the mechanical tenderness technic. We are now actually engaged in separating the amino acids, and we do find differences. We do find definite differences in the amino acids on our meat-o-graphs, between muscle from tender animals and muscle from tough animals or between two muscles from the same animal, one being tender and one being tough. We are now in the process of trying to identify these amino acids or acids and to relate them in our panel testing.

We are also using pressure to determine tenderness and, as reported at the AMIF meeting, we have a correlation of .899 between the pressure required to exude juice from a pressure sample as compared with a palatability committee which tested the meat after 10 days. That probably is as high a correlation as I have seen with objective procedures. We hope to increase the size of our cylinder, so that we can take a small biopsy sample from the semitendinosus of a round of beef.

MR. COLE: The Chairman says our time is up but I think we want to take just a minute or two more.

MR. KING: I just want to ask Mr. Cole if he would mind divulging a few of his secrets. He has done some of this work, too, and he has been mighty quiet about it.

MR. COLE: We have not done anything spectacular. We have just been doing routine work which we know is the tedious separation, and I don't think we are ready to report anything as yet. We do have some interesting work on types and breeds and I for one am anxious to find out -- we might have a word to say after we receive the report over here. Bob Dynes and Carroll Schoonover helped us to do the work. Let's see what it looks like.

Question No. 1: What grade of beef would you purchase if you were going to put it into your locker as a whole side? What is the total number by the way?

MR. SCHOONOVER: I don't know. We didn't tabulate it.
Beef Carcass Evaluation Committee

Questionnaire - 11th Reciprocal Meat Conference 1958

1. What U. S. D. A. grade of beef would you purchase, if a whole side were to be processed for your locker or home freezer?

- Prime 2.2%
- Choice 46.7%
- Good 47.8%
- Std. 3.3%

2. Indicate the U. S. D. A. grade you would prefer for each of the four sections of the beef side shown on diagram. Take into consideration the usual retail cuts obtained from each section.

Grade Preference

Section 1
- P 15.6 - Ch. 46.9 - Gd. 34.4 - Std. 3.1

Section 2
- P 9.6 - Ch. 64.9 - Gd. 24.5 - Std. 1.1

Section 3
- P 2.1 - Ch. 22.3 - Gd. 67.0 - Std. 8.5

Section 4
- P 0.0 - Ch. 3.2 - Gd. 44.1 - Std. 48.4 - Util. 4.3

Remarks:

Approximately 100 participants

(optional) Name ____________________

AH 44-58
MR. COLE: We have 2 in prime, 42 in choice, 43 in good, and 3 in standard. It looks like it is a toss-up between choice and good.

The second question, section 1, refers to the round broke down in fourths. How many of you realized that a side of beef could be broke down in fourths like that? That is the Meat Board style. Those are the percentages right off of the Meat Board chart. Two prime, 42 choice, 43 good and 3 standard. Someone put down the utility grade. Outside of that they use only four grades. Of the No. 1 section, which is the round, 15 out of the -- it looks like 96 people -- 15 out of the 96 people, which is actually about 15 per cent, prefer prime, 45 choice, 33 good and 3 per cent standard.

On the next one, on the loin rib section, 9 per cent prime and 61 per cent choice. That is a surprise to me. I thought more than that would take prime. Twenty-three good and only one standard.

Then on the third section, which is the chuck section, 2 per cent prime, 21 per cent choice, 63 per cent good, and 8 per cent standard.

In the thin meat section, the belly section, no takers on prime, 3 on choice, 41 on good, 43 on standard, and 4 on utility.

That points up one thing. I will have to admit that I sort of forced this on the committee -- this survey and that is the complexity of beef carcass evaluation work. I do not feel that we can concentrate on one section and do a good job. In other words, if we do all our work on the rib section or the loin section, we are eliminating maybe 75 per cent of the carcass when we see quite a variance in grades. That also points out that the beef animal is far from being perfect in any grade, because we don't seem to have anything we want in, say, a side in any one of the grades. It makes no difference what it is.

Now I am going to conclude by saying that I know we do have a fat problem in beef carcass evaluation work. Maybe we are no better off than the pork people. I do feel that probably in pork evaluation there has been quite a bit of negative thinking on the meat type hog and that the way to produce them is to remove the fat, but that is just half the problem, I think in beef carcass evaluation. I hope that we are not accused of taking a negative approach. I think that we should assume a positive approach which is a more edible portion of high eating quality.

Thank you. (Applause)

CHAIRMAN CAHILL: I think that is a very excellent note on which to end the formal part of our two-day conference. I realize that the discussion periods have not been long enough for some of you to get your questions answered; so I implore you to corral the individuals whom you might think are able to answer your questions and discuss them to your heart's content during the remainder of the evening and possibly the next day or two.

I believe that Don Naumann has an announcement concerning the Teaching Committee.
MR. NAUMANN: I had lunch with Ken Franklin and I pointed out to him that the syllabus of the basic meat course, to which we referred in the Teaching Committee, is not in the previous proceedings of this conference. It will be included in this year’s proceedings.

(See conclusion of proceedings for the syllabus)

Thank you.

# # # # # # #

CHAIRMAN CAHILL: I believe that we are ready for our business meeting. If we follow the normal and preferred scheme of handling the business meeting and if you folks should vote in a certain way that would create the necessity for a ballot vote, we will find ourselves in a rather time-consuming situation. So with your permission I wonder if we might deviate a little and pick up at the beginning of our business meeting a point which we left last night.

Yesterday morning we made an announcement concerning some letters up here on the table. Yesterday afternoon, at the end of our afternoon session, we discussed it a little further. I am referring, of course, to the question as to whether our 1959 conference will be held in Chicago or elsewhere. I wonder if you would like to consider that as the first item of business in our meeting today.

MR. KEMP: Mr. Chairman, I move that we vote on whether or not to have it somewhere else by a show of hands.

CHAIRMAN CAHILL: You have put that in the form of a motion. Do you want to make it one way or the other?

MR. KEMP: I move that in 1959 only. I am only referring to next year.

CHAIRMAN CAHILL: That the 1959 conference -- we need a positive approach, I think, Jim.

MR. KEMP: I move that the 1959 conference be held on a campus.

MR. KUNKLE: I will second that motion.

CHAIRMAN CAHILL: It has been moved and seconded that the 1959 conference be held on one of the campuses.

MR. NAUMANN: For your consideration, I would suggest that unless we vote on this every year we might consider changing that motion to put it in