DETERMINING THE TENDERNESS OF MEAT BY USE OF THE WARNER-BRATZLER METHOD

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Before discussing the subject assigned to me, I would like to emphasize the fact that neither Mr. Warner nor myself patented the original machine or the revised apparatus. I believe an attempt was made to secure a patent on the revised apparatus, but because the original device was described in literature, it was not possible to patent the device which is now known as the Warner-Bratzler Shear or Tenderness Machine.

There are, at present, three recognized methods used for determining the tenderness of meat. These are the palatability method, chemical analyses, and the physical or mechanical method. My subject definitely limits this discussion to the last named method, and particularly to a machine of the shear or mouse trap type.

Mechanical determination of tenderness of meat was first done by Lehman and workers in 1897, results of which were published in 1907. Tressler and co-workers described two devices, a cutting gauge and a penetrometer, in connection with their quick freezing of meats. Winkler also described an apparatus with a recording device that measured the amount of work performed by removing a core of meat of uniform diameter. Warner described his original mouse trap type machine in 1928 together with the highly significant correlation obtained on the repeatability of the device.

This original machine was most widely accepted and a number of them were used by experiment station workers. While they were of the same general type, there were variations in detailed design which did not make results from the various workers entirely comparable. Through the cooperation of the Animal Husbandry Division of the Bureau of Animal Industry and the Kansas Experiment Station, work was done on the standardization of the machine, the final result was the apparatus known as the Warner-Bratzler Shear.

Briefly, the machine measures the amount of force necessary to shear through a sample of meat of given diameter. Most of the work done and reported in the literature has been with the one inch diameter cylindrical cores of meat. In recent years some of the workers have used the one-half inch diameter cores.

The standardized, or revised, machine uses a shearing blade .040 inches in thickness. The opening in the blade is made by circumscribing an equilateral triangle about a circle one inch in diameter. The cutting or shearing edge of the opening is rounded or dulled to the radius of a circle of .02 inches. As most of the machines are motor driven, a shearing speed of 9 inches per minute is used. While the amount of force necessary to shear the sample is recorded on a dead hand spring dynamometer, I can see no reason why any similar recording device in pounds can not be used. I understand that some machines at various stations are equipped with a hydraulic recording device.

Through correspondence with The G-R Electric Manufacturing Company, Manhattan, Kansas, I have found that the present approximate cost of the

apparatus complete with motor is $285.00; without motor $277.00. Professor Mackintosh of Kansas State College states that blueprints of the machine are available for those who would prefer to construct their own machine. Specifications can be obtained from the Animal Husbandry Department of Kansas State College, while the machine is manufactured by The G-R Electric Manufacturing Company.

It might be well to consider some of the correlation values obtained by the various research workers interested in determining the tenderness of meat. Warner, in his report of 1928 with the original machine before modification, obtained correlation coefficients of .87 and .79 between right and left ribs of 100 and over 100 pairs of beef ribs respectively. In the same report, he states that the correlation between raw shearing values and cooked shearing values was .3, which was the same value obtained when comparing raw shear values with palatability committee scores on the cooked rib roasts. When comparison was made between cooked shear values and committee scores, a correlation coefficient of .79 was secured. It can be seen that excellent relationships between shear values and committee scores were obtained on this original apparatus. This machine differed from the modified version by having a thicker shearing blade with a sharp edged circular opening, in addition to being hand operated.

In chronological order, the Kansas work in connection with modifying the original design would follow. Using the Warner-Bratzler Shear, the following correlation coefficients were obtained on 32 roasts with shear values taken as an average of from 5 to 7 readings per sample and committee score averages of 5 or more persons.

Cooked shear values with raw shear values - - - $r = .439$

Cooked shear values with committee scores - - - $r = -.907$

Raw shear values with committee scores - - - $r = -.414$

Lowe, in 1934, concluded that the shearing device measured tenderness more accurately than the penetrometer, since the shearing results were in agreement with the grading scores, while none of the correlations between penetration and shearing tests were significant.

Mackintosh, Hall and Vail, in 1936, reported correlation coefficients of -.60 and -.986 when comparing cooked shear values with palatability committee scores on 61 and 45 samples respectively. They also found a significant correlation between cooked shear values and collagen nitrogen.

Brady, in 1937, found that a significant relationship existed between cooked shear values and tenderness scores as well as between the same shear values and the diameter of muscle fibers.

Using 36 samples of pork and beef roasts, Satorius and Child obtained an r value of -.69 between cooked shear values and committee tenderness scores. Highly significant correlations were also found between shear values and diameter of muscle fibers and between shear values and number of muscle fibers per bundle.

In 1944, Paul, Lowe and McClurg reported on the changes in histological structure and palatability of beef during storage. Dr. Paul calculated, and was kind enough to give me, the correlation coefficient she obtained between cooked shear values and palatability committee scores. With shear values ranging from 10 to 93 and committee scores from 1.75 to 10.00, a highly significant correlation of -.784 between the two measurements of tenderness was obtained.

All of the results thus far mentioned have been on the use of the one inch diameter cylindrical cores of meat. Recently some of the workers have been using one-half inch diameter samples. I believe Swift & Company, the Beltsville people, also Cornell and we at Michigan have done work using the smaller samples.

In order to obtain information as to the relationship of values obtained from the two sized sample cores, Dr. Paul, Mr. Farwell and myself made 363 tests on deep-fat cooked steaks from the semi-membranosus muscles of three steers ranging in grade from good to choice. Adjoining paired samples were taken from each steak, the number of pairs being dependent upon the individual steak size. As few as two pairs of readings were obtained from some steaks and as many as seven pairs were secured from the largest steaks.

In analyzing the individual paired readings, a highly significant correlation coefficient of .553 with a standard error of estimate of 4.61 was obtained. When the values for each of the 89 steaks were averaged, as is generally done in reporting tenderness differences, another highly significant correlation of .761 with a standard error of estimate of 2.88 was obtained. The estimating equation for the latter comparison was found to be $Y = 1.817x + 5.805$; x and y being the one-half and one inch sample values respectively.

In some additional work, Dr. Paul and Miss Orr have used the one-half inch cores as well as committee tenderness scores on deep-fat cooked steaks. With a range in cooked shear values from 6 to 25 and committee scores from 1 to 4.8, a highly significant correlation of -.747 was obtained.

The Kroger Food Foundation of Cincinnati, Ohio, prefers to use an organoleptic panel in determining differences in tenderness of meat. Through the courtesy of Mr. George Garnatz, Director of the Foundation, I was able to get some of their data from which I took the liberty to compute correlation coefficients. In comparing differences between control and Tenderay treated beef shortloins, using both the panel and the shear machine on two series of 32 tests each, correlation coefficients of -.399 and -.299 respectively were obtained on panel scores and cooked shear readings. When the two series were combined into one set of 64 tests, a highly significant r value of -.435 was obtained. I was interested in checking the repeatability of the panel and the machine and found that both methods gave highly significant correlation coefficients of .786 and .780 respectively. This comparison was made between the untreated and treated samples tested by both methods. I would like to quote in part from Mr. Garnatz's letter as follows: "The machine in general parallels the panel results, but we are of the opinion that it is less sensitive to differences than is the panel. In testing with the machine, one must be constantly on the lookout for specimens with heavy connective tissue. Such specimens give abnormal results because the connective tissue becomes wedged between the shear plate so that the machine measures the tensile strength of such tissues rather than the shear strength of the meat."

In summarizing the reported results of tenderness work done to date using the Warner-Bratzler Method, it can be said that the apparatus gives values that are in agreement with taste panel evaluations.

Undoubtedly there are many factors which affect the values obtained from the machine. Some of the more important ones are as follows:

1. Degree of doneness of the cooked sample. Normally, the more doneness, or higher internal temperature, the higher the readings. Conversely, rare cooked meat tends to give lower values.

2. Uniformity of samples. Lack of care and attention in removing the core samples may result in hour-glass shaped cores. Very light pressure in connection with a rotating clockwise and counter-clockwise motion tends to give sample cores with minor differences in diameter from end to end. Personal experience and observation indicates that a three inch roast cut into 3 slices and then sampled will give even more uniform cores.

3. Muscle Fibers. Samples should be taken parallel with the direction of the majority of muscle fibers. Even in the longissimus dorsi muscle, the majority of the muscle fibers are not parallel to the long axis of the muscle. Here again, the sampling of narrower slices facilitates the sampling problem.

4. Presence of connective tissue and fat deposits. Either of these deposits should be avoided in sampling. The one-half inch sampler is particularly valuable in this respect as the cross sectional area of a small muscle eliminates much choice of sample position when using the one inch sampler.

5. Temperature of sample and speed of shearing. Very little work has been done on these factors. Personal experience tends to indicate that under normal temperatures and slight variations in shearing speeds, little, if any, effect on readings results. The main consideration to be kept in mind is that the shearing should be done at a constant, steady rate of speed.

Realizing that my estimation of the Warner-Bratzler Method for determining tenderness of meat might be biased, I feel it can be concluded that it is probably the most widely accepted and utilized method at this time. I am certain that a better method can be devised or discovered by the combined efforts of correctly trained investigators in the fields of engineering, foods, consumer acceptance, chemistry, anatomy and meats research.

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CHAIRMAN BUTLER: Thank you for those cutting remarks.

We will now be charmed by our discussion leader from Texas, Stanley Anderson.

PROF. ANDERSON: Thank you, Mr. Chairman.

I am sure Mr. Bratzler has given us interesting information on the testing of meat.

Are there any questions you would like to direct to him?

PROF. COLE: I am wondering if there have ever been any studies done on the length of the core, whether that will have any effect on the test -- whether a half-inch would shear at less pressure than an inch, and so forth.

PROF. BRATZLER: You mean if the core of the sample was that long (indicating), or that (indicating) long?

PROF. COLE: Yes.

PROF. BRATZLER: As long as you do not get any of the fibers, either connective tissue or any fiber that you have pulling through, I do not think it would make any difference. You want to be sure, particularly when you are sampling that way, that you have the same degree of doneness. You encounter the same condition in your panel testing that Miss Lowe talked about by having one person sample the same slice from each roast. Of course, we feel that by using the half-inch sampler, if we can get seven readings where ordinarily we would only get two or three with the inch sampler, it gives us a better or more reliable measure.

Does that answer your question?

PROF. COLE: I might ask one more. If you take seven readings, do you average all seven?

PROF. BRATZLER: Yes.

PROF. COLE: Or do you take the three closest ones?

PROF. BRATZLER: No. It is the old story that figures do not lie.

PROF. ANDERSON: Are there any other questions? If not, I will turn the meeting back to the Chairman.

CHAIRMAN BUTLER: Thank you, Mr. Anderson.

Now, at this time I believe there has been a slight change in the program, and I will turn the meeting to the General Chairman, Mr. Tomhave.

. . . Mr. Tomhave resumes the Chair . . .

CHAIRMAN TOMHAVE: Thank you, Professor Butler. We have had a most interesting session this morning. I am sure that you will all agree with me that the papers that were presented contained most valuable information and that the subjects were so thoroughly covered in all cases that there was little occasion for questions or discussion.

Since it is now past twelve o'clock, we ask your permission to transfer Mr. Hiner's paper to the afternoon session and adjourn for lunch.

According to the original schedule, we are allowed an hour and fifteen minutes for lunch, but because of the absorbing interest in the morning program we are going to take just one hour for lunch. We stand adjourned until 1:10.

. . . The meeting adjourned at 12:10 o'clock p.m. . . .

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