Traditionally, scientists have measured shear force to make comparisons among breeds or treatments in an experiment at their institution. They did not know if the measurements were accurate but they were repeatable enough that treatment differences were frequently detected. There was usually no need to make direct comparisons, other than observations that values in the literature were frequently smaller or larger than theirs. But these differences could be dismissed because the animals were simply different in tenderness than those they had used.

A series of events occurred which resulted in our interest (at the MARC) in improving shear force measurement. The first was that we began trying to predict meat tenderness. This meant that it was much more important that a measurement on an individual animal be more accurate than in the past. This was true because treatment comparisons gave us the opportunity to average a given number of observations per treatment, thus allowing us to “average out” the error in the shear force measurement and still find treatment differences. But if the measure for each animal had to stand on its own, this error was no longer allowable. It also became apparent that much-needed consumer evaluations of meat tenderness would soon be available, but for them to be meaningful to institutions that had not collected the data, they must be able to relate their shear force measurements to those of the institution(s) that had collected the consumer data. It was also becoming more and more obvious that different institutions’ shear force values were not the same. In some cases, differences in measurement protocol could be responsible; but in others the reason(s) was not so obvious. Finally, one outcome of the NCA’s National Beef Tenderness Conference was a call for uniform standards for collecting shear force data for evaluation of genetic differences in tenderness.

Factors Evaluated

These reasons initiated our interest in evaluating factors potentially affecting shear force values, and in determining if they were different among institutions; if so, by how much and why? This reciprocation session involved presenting data on some of the factors we have evaluated for their effects on measurement of shear force, and demonstrating those effects for core orientation. We also introduced the potential of using pencil eraser material as a standard to determine if there are inherent differences in shearing instruments at different laboratories.

Several factors that were evaluated had no affect on shear force values. These included: Use of Instron compared to Warner-Bratzler machine; obtaining cores after cooling steaks to room temperature compared to chilling steaks overnight (Table 1); obtaining cores by hand compared to using a machine; cooking steaks by Farberware Open-Hearth broiling compared to modified-oven broiling; turning steaks every 5 min compared to turning of the steaks after they reach 40°C internal temperature, and location of the steak on the Farberware Open-Hearth grill surface.

Several factors were evaluated that did affect shear force values. These included: Obtaining cores parallel to the fiber orientation compared to perpendicular to the steak surface (Table 2); the extent of thawing of frozen steaks before cooking; holding steaks at the endpoint temperature after cooking before allowing cooling (such as might occur during sensory evaluation if steaks are done before the panel is ready); and the institution where data were collected. Better standardization and control of the factors identified as important in measuring shear force should make them more accurate and repeatable.

Some attendees indicated that the Warner-Bratzler machine could or could not be calibrated. A call to the manufacturer

| Table 1. Effect of Steak Cooling before Coring on Shear Force Values. |
|--------------------------|-----------|---------|------|
| Protocol                 | n   | Mean, kg | SD   | Difference |
| Chill 24 h, 3°C          | 57  | 6.15    | 1.75 | .15         |
| Cool 30 min, 23°C        | 57  | 6.00    | 1.89 |            |

From Wheeler et al., 1994.

| Table 2. Effect of Core Orientation on Shear Force Values. |
|-----------------|-----------|---------|------|
| Orientation      | n   | Mean, kg | SD   | Difference |
| Parallel         | 57  | 6.31    | 1.85 | 1.80        |
| Perpendicular    | 57  | 4.51    | 1.12 |            |

*Parallel=parallel to the fiber orientation, Perpendicular=perpendicular to the steak surface. From Wheeler et al., 1994.
(Tennison Collins of G. R. Electric, Manhattan, KS) confirmed that there is a screw to set the zero point, but if a known weight hung from the scale does not read correctly, that scale cannot be adjusted and must be replaced or refurbished. He also said that machines made before 1960 have a shearing blade with different sharpness and thickness.

A common question asked was how many cores per steak should be obtained. Answers ranged from six to fifteen. We recommended using six uniform diameter cores that represent the entire muscle cross-section with no visible defects (such as a large chunk of connective tissue). There were questions about the ability to obtain cores perfectly parallel to the fiber orientation. Though it may not be as easy as simply drilling cores out perpendicular to the steak surface; with training and practice, cores parallel to the fiber orientation can be obtained with a high degree of accuracy.

Should outlier values or values from cores with a piece of connective tissue running through them be discarded? We think that a core with an obvious defect should not be used because it would not be representative of the shear force of the steak. However, a value should not be discarded simply because it is an outlier. We know there is inherent variation across a steak. So, an outlier value should not be discarded unless there is an obvious defect that warrants its removal.

An unanswered question at this time is: Are there inherent differences among instruments used to obtain shear force? Hopefully, we will soon be able to use the eraser material as standards to answer this question.

**Conclusions**

Based on currently available data, the following conclusions can be made:

- Cores should be obtained parallel to the fiber orientation.
- Instron or Warner-Bratzler machines can be used to shear the cores.
- Extent of cooling prior to coring is not critical.
- Frequency of turning a steak during cooking is not critical.
- Location of the steak on the Farberware grill surface is not critical (as long as only four steaks are cooked at a time).
- If frozen steaks are thawed before cooking, the extent of thawing is critical and should always be the same (i.e., always thaw to the same temperature, since warmer thawed temperature gives lower shear force).
- Holding steaks at 70°C after cooking for 30 min before cooling increased shear force (eliminate or standardize holding time).
- Location within the *longissimus* from which the steak was obtained is not critical, as long as cores are parallel to fiber orientation.
- Farberware Open-Hearth broiling was not different in shear force value from modified-oven broiling. We also have just completed a comparison of Farberware Open-Hearth broiling vs Farberware Oven broiling, indicating the same result. Moreover, these cookery methods resulted in the same level of repeatability of shear force.
- Obtaining cores by hand or by drill does not affect shear force, although we think more consistently uniform cores can be obtained by machine (either way, the corer must be sharp so that the “hour-glass effect” is not obtained because too much pressure had to be used to make it cut).
- As currently collected, there is wide variation in results from different institutions.
- Although cores obtained parallel to fiber orientation provide more variation in shear force attributable to animal and give more repeatable shear force values, it is not yet known if shear force from parallel cores correlates better to sensory tenderness rating than shear force from perpendicular cores.

**Reference**