15. Objective Analysis of Tenderness

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Learning objectives

At the end of this lecture you will be able to:

- Describe the tests available for objective measurement of tenderness
- Interpret the results from these tests
- Discuss their usefulness

15.1 Introduction

Whilst humans are the final arbiters of eating quality, there are a number of drawbacks to their use (eg, cost, time, variability). Over the years a number of mechanical devices have been developed for the objective measurement of tenderness. They are consistent, relatively cheap, repeatable, reliable, and not influenced by human bias, preference or by external irrelevancies. This lecture will cover their usage and how well they correlate to sensory assessment.

Objective measurement

When consumers eat meat they perform a number of actions.

- a biting shearing action
- a squeezing action
- a stretching tearing action

A number of instruments have been developed to objectively measure these actions. No one machine can mimic all actions. Measurements are done on cooked samples. Cooking method and temperature may vary between protocols, but must be standard within an experiment.

There are a number of benefits associated with using mechanical devices for tenderness estimation. Using machines provides an objective measurement, the repeated use of a standard device gives reliability, repeatability, standardisation, and is relatively quick and easy.

Unfortunately these objective measurements are not able to incorporate into their measurement, other sensory attributes which influence consumers’ assessment of meat tenderness. This is one of their limitations. They only provide an estimate of the physical toughness of meat. Measuring the physical properties of meat will confer an understanding of the tenderness of the meat, but ultimately these measurements must relate to the way the meat behaves in the mouth when consumers eat it. The method of evaluation used in studies will depend on the aim of the experiment. The other difficulty with evaluation meat is that it is an extremely heterogenous product and often variation exists within a single muscle which makes multiple evaluations essential.

15.2 Shear force

The traditional Warner Bratzler (WB) shear device used a triangular hole in a shear plate, which was drawn between two bars (see B Figure 15.1). Cylindrical cores of meat were cut from the cooked meat sample. Dr Robin Shorthose from CSIRO Cannon Hill proposed a modification in which used a square hole and a rectangular cross-sectional core (of dimensions such that the cross dimensional area is exactly 1 square cm).
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Figure 15.1 Some of the ways to measure meat texture. Blunt jaws (A) Warner-Bratzler shear (B), Armour-type tenderometer (C), electric meat grinder method (D). Instron test for ten properties (E), and meat glued to a clamp (F). Source: Perry, (2006).

This modification was to ensure that the shear blade - sample contact area was constant. This is shown in the diagram and photograph below. It is important that the sample is cut so that all fibres run in the same direction. It is recommended that the fibres run parallel to the base plate, so that the blade shears through them at right angles. A blunt blade is used, so that samples are shorn through, not cut.

Figure 15.2 Modified shear device. Source: Perry, (2006).

The force necessary to shear through a standard sample is measured in kilograms or newtons, using a load cell. A typical deformation curve from a shear sample (Figure 15.3) shows an increase in force to an initial yield and then to the maximum peak force. Most studies quote only peak force. Initial yield is predominantly a measure of the connective tissue component of toughness. Peak force measures mainly the myofibrilla component of toughness.
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Figure 15.3 A force curve from a shear device showing peak force. Source: Perry, (2006).

It is not possible to directly compare measurements taken using different protocols or machines, as shear force will vary with the dimensions of the sample, of the blade, and the speed at which the blade moves. Cooking method and temperature also affect tenderness. These need to be standardised within experiments, but are not necessarily the same in different laboratories. However, regardless of the method used, the higher the force needed to shear through the meat samples, the tougher the meat.

In the Meat Science laboratory at UNE samples (250g for beef) are cooked in a water bath for 1 hour at 70°C, cooled in running water for half an hour and then held overnight at 12°C before analysing. This is equivalent to a medium degree of doneness. The device used is similar to that developed by Shorthose, attached to a Lloyd Instruments Materials Testing Machine fitted with a 500N load cell (Figure 15.4).

Figure 15.4 The Lloyd texture meter fitted with a modified shear device. Photographs supplied by D. Perry.
15.3 Compression measurement

The compression measurement was designed to assess the elasticity factor of the connective tissue. A flat ended cylindrical rod is pushed twice into the meat at the same location. The variables measured (Figure 15.5) are:

- hardness: peak on the initial penetration
- cohesiveness: the ratio of work done on the first compression compared to the second compression
- chewiness/compression: the product of hardness and cohesiveness

As with shear force, fibre direction is important. It is recommended that fibre direction is at right angles to the direction of the rod. Compression is also measured in kilograms or newtons, the higher the value the tougher the meat.

Figure 15.5 Force curves from the compression test. Source: Perry, (2006).

![Force curves from the compression test](image)

Figure 15.6 The Lloyd texture meter with compression attachment. The plunger is pushed into a meat surface perpendicular to the fibre direction. Photographs supplied by D. Perry.

![Lloyd texture meter with compression attachment](image)
15.4 Adhesion measurement

The adhesion test measures the breaking strength of muscle samples. A sample of meat is attached to clamps with the muscle fibres running from one clamp to the other. These clamps are drawn apart until the muscle fibres break the force at the initial breakage is recorded. Once again the higher the value, the tougher the meat (the more force is needed to fragment the meat).

This is a much more variable measurement than shear force and compression and is not always measured. As with compression and shear force, standardisation of samples as to size and fibre direction is essential.

Figure 15.7 The adhesion test being performed. Photographs supplied by D. Perry.

15.5 Relationship between objective and subjective measurements of tenderness

The relationship between sensory evaluation and objective measurement of meat tenderness is influenced by a variety of factors.

Bouton et al (1975) demonstrated that over 75% of the variation in tenderness, as assessed by a trained taste panel, could be explained using Warner Bratzler shear values, compression values and cooking loss measurements. Shackelford (1995) showed that the strength of the relationship between sensory panel scores of overall tenderness and shear force measurements varied widely with different muscles ($R^2=0.00$ for *M. gluteus medius* to $R^2=0.73$ for *M. longissimus thoracis et lumbarum*). Such differences are indicative of the weaker relationship between tenderness in high connective tissue muscles and objective measurement of tenderness by devices which primarily measure myofibrillar toughness (e.g. shear force). Any post slaughter treatment which alters the relative contribution of the myofibrillar and connective tissue component to the toughness of muscle may also affect this relationship, though not necessarily that between assessment by trained taste panel and untrained consumers.
An analysis which investigated the relationship between trained taste panel scores, consumer scores, and objective measurements in beef samples which had a combination of electrical stimulation (or not) and ageing (or not) was reported by Perry et al 1998. This paper is included as a reading for this lecture. Briefly, the conclusion reached was that trained taste panel scores had a good correlation with consumer scores and this was not affected by post-slaughter treatment of the meat. The relationship between objective measurements and consumer scores was reasonable, but the usefulness of peak force and compression differed in aged versus non-aged samples.

Readings
There are no readings for this topic

Summary
Summary Slides are available on web learning management systems

- objective measurements are standardised, repeatable, reliable
- no one device can mimic human mastication
- shear force and compression are the two most common objective measurements
- shear force measures mainly the myofibrilla contribution to toughness
- compression measures mainly the connective tissue component of toughness
- standardisation of sample preparation and orientation is critical
- you can’t directly compare force values obtained under different protocols
- there is a good relationship between objective measurements and consumer scores
- the most useful measurement in predicting consumer scores will depend on post-slaughter treatments

References