RECOMMENDATION OF REFERENCE METHODS FOR ASSESSMENT OF MEAT TENDERNESS

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S-V.06

1. Introduction

As an integral part of the OECD research project "Management of Biological Resources" it was suggested that expert committees should consider reference methods which could be applied to quality attributes of meat. In 1993 Barton-Gade _et al_ (1993) considered reference methods for Water Holding Capacity. The same approach is continued here for Tenderness evaluation methods.

Methods for the assessment of meat tenderness are extremely variable in terms of approach and usefulness. Although some attempts at standardization have taken place for instrumental (Boccard *et al* 1981) and sensory techniques (Anon 1978) they do not appear to have been universally accepted. As cooperative research efforts increase, it is essential that methods be standardized, so that results are directly comparable.

Although tenderness is important in both whole tissue and processed meats the methodology discussed here has been restricted to whole tissue products, recognizing the multitude of differences that can exist with processed products.

In considering reference methodology it was recognized that tenderness evaluations could be applied for at least three different reasons:

a. As a quality assurance (QA) tool, within a processing operation,

b. As an assessment of the effectiveness of production and processing treatments, where there may be an interest in being able to compare results between laboratories or countries,

c. As a research tool, in fundamental structural studies of muscle and meat.

In the first case, a common methodology need only be appropriate for the plant or group of plants being controlled by specific QA programmes. The methods used should measure the desired characteristics necessary to monitor the process, but need not be comparable with other laboratories, where different criteria may be important.

Where international comparison is important it is essential that methodology be standardized. This would include all aspects of the testing procedure and it is this aspect to which the reference methods are primarily directed.

Where assessments are being made of the mechanical properties of meat as a function of structural (chemical or physical) changes methodology should not be constrained by reference methods. Instead researchers are encouraged to develop and use methodologies which enhance differences and lead to an understanding of the basic mechanics affecting tenderness. It is likely that it will be from this area that new understanding will develop and lead, eventually, to methods which more closely predict consumer assessments of tenderness.

The three methodologies described will provide information which can be related to consumer sensory assessments. Each method has its advantages and limitations with no single method providing complete information. All of the tests can be carried out in any of a wide variety of noncompliant test frames e.g. Instron Universal Testing Instrument.

In describing the methods we have started from the initial premise that conditions must be well defined regardless which methodology is being used.

2. Sample Description and Preparation Methodology

2.1 History and Specification of the Meat

The origin and treatment of the live animal, the slaughter and post-mortem handling should be described as precisely as possible, e.g. species, breed, sex, age, feeding regime, transport and preslaughter/handling, slaughter conditions, chilling and ageing regime. The rate of pH and temperature fall post-mortem and final pH of the muscle studied should be reported. It is not always possible to know all of the history nor is it always important but if it is known it should be reported.

2.2 Sampling

The muscle most widely used is the M. Longissimus thoracis et lumborum. The sampling location must be clearly described (e.g 11 to 12 thoracic rib). Other muscles will also be tested and, when used, should be described with similar precision. It is recommended that, where possible, a slice, perpendicular to the longitudinal axis of the muscle with a length of at least 50 mm along the fibre axis be used. This allows preparation of test specimens for all of the recommended test methods.

2.3 Storage of Samples

If possible assessments are to be performed immediately but when storage of samples is necessary, meat should be frozen. The slices should be vacuum packed and frozen quickly. They must be stored at -18°C or below. Storage should not exceed 3 months. Thawing must be carried out under standardized conditions. Slow thawing and prolonged holding after thawing will allow further aging. The effects of freeze/thaw cycles on tenderness are variable (Locker and Daines 1973) and in some circumstances might affect the results.

2.4 Heating (Barton-Gade *et al.* 1993)

Individual slices, or standard weighed block of meat, in thin walled plastic bags, are placed in a waterbath with the open bag end extending above the water surface. One hour heating at 80°C (well done) is recommended although temperatures of 55°C (rare), 65°C (medium) and 95°C (thoroughly cooked) can be used in relation to the nature of the meat and the preparation considered. Samples are removed from the waterbath and cooled for 30 minutes in running tap water and then held at 4°C until tested.

2.5 Testing

Specimens should be equilibrated to the temperature used for assessment, this will usually be the ambient temperature. Regardless of test methodology it is recommended that 10 specimens be tested but the minimum number should be 6.

3. Tensile Test Method

3.1 Introduction

The tensile test will be best suited for structural investigations (Purslow 1985) rather than used to predicting sensory results, but may become a useful general test methodology in conjunction with other methods. The test can be carried out on raw or cooked meat but if it is conducted on cooked meat the cooking procedure should be that specified earlier. Results will be affected by sample size and by strain rate but this latter effect will be small. Gripping problems will be the major cause of rejection especially with raw meat. Cyanacrolate adhesives may be used or freezing grips can be employed (Lewis and Purslow 1991).

3.2 Methodology

The block of cooked (or raw) meat should be sliced, with a thin-bladed sharp knife, to produce least damage, into thin slices. The standard thickness will be 3.5 mm but for some species and some muscles thinner slices will be required. As testing may be conducted transverse or parallel to fibre direction, slicing will also be either parallel to or transverse to the muscle fibre direction.

From the slices (3.5mm) tensile test samples will be cut using a template to define dimension and shape. The template shape is shown in Figure 1. If smaller samples are required due to physical restrictions imposed by muscle size and shape then the proportions of 4:1:0.5 in terms of length:width:thickness should be maintained.

When cutting the samples to the dumbbell shape a continuous cut to produce a smoothly contoured surface is required. Great care should be taken to ensure that fibre direction is parallel or transverse in both thickness and width views of the longitudinal axis of the dumbbell. Dumbelling is less important for tensile tests transverse to the fibre direction where parallel sided strips may be used provided that a/ fracture occurs away from the edges of the grips and b/ a length between grips to width ration of 4:1 is maintained.

Width and thickness of the samples after cutting should be measured with vernier callipers again taking care not to damage the sample. When the degree of variation is established it may not be necessary to measure every sample. However it must be recognised that the cross sectional area of the sample will affect the results obtained.

Specimens will be subjected extension at a strain rate of 2/minute (i.e. strain rate = extension rate/specimen length). e.g. for the recommended 28 mm gauge length an extension rate of 56 mm/min would be recommended. A rate of 50mm/min would be acceptable on test machines with limited preset speeds.

The sample will normally be gripped with pneumatic clamps with operating pressures reduced to maintain firm gripping without obvious slippage yet minimize specimen damage.

A load deformation curve to complete rupture should be obtained. Criteria for acceptance of test results is that fracture occurs in the parallel sided region of the specimen. The parameter to be measured is breaking stress (i.e. Breaking stress = peak force / measured width x thickness). The results should be given in Pascals. (Pa equivalent to N/m^2). Other parameters can be taken, for example Energy under the curve and Breaking Strain (Breaking strain = Extension of peak force/Original gauge length).

4. Warner Bratzler Shear Test

4.1 Introduction

About 80% of researchers use 'Shear' tests such as the so-called Warner Bratzler (W-B) shear device to evaluate meat tenderness. The devices and the methods used are not identical since there is no standardization in blade shape, thickness or sample shape and configuration (Voisey 1986). Both blade and sample shape can vary (e.g. Cylindrical or rectangular sample crosssection and triangular or rectangular shaped hole in the shear blade). Rates of shearing used also vary (but these differences may not be important).

The influence of cooking temperature on force-deformation is large. At cooking temperatures up to 60°C connective tissue influences predominate and above that myofibrillar components are more important.

Correlations between Warner Bratzler Peak Force (WBPF) values alone and sensory tenderness scores are greatest in a given muscle between animals of the same age (provided cooked to >60°C) whereas correlations between sensory scores and Warner-Bratzler shear force are least when different muscles from animals of different ages are compared (Harris and Shorthose 1988).

WBPF measurements are most useful when the influence of connective tissue is low and variations in the myofibrillar component are to be measured. e.g. differences due to prerigor -muscle shortening, ultimate pH or ageing.

4.2 Instrument

The WB shear device should be as follows:

The blade should be 1.2 mm thick with a rectangular hole 11 mm wide and at least 15 mm high. The hole should have square edges but the edges should not be sharp. The blade should be drawn or be pushed at 50-100 mm/min between side plates positioned to provide a minimum gap between blade and plates. A means of holding the sample may be required with some configurations.

The forces exerted in shearing the sample should be recorded so that the peak force (WBPF) and total energy can be obtained. Other yield points (e.g. initial yield) are useful but may not be apparent in some systems or with some samples.

4.3 Sample

The sample to be tested should be cut from a block of cooked meat ensuring care is taken to avoid damage. Sample strips should be cut with a 100^2 mm square crossection and fibre direction parallel to a long dimension of at least 30 mm. The sample should be sheared at right angle to fibre axis.

4.4 Parameters Measured

The parameters to be measured from the force deformation curve (Figure 2) are the peak force (the maximum recorded) and the total energy. Initial yield (IY) may be useful in some instances but will not always be apparent.

5. Penetrometer Measurements

5.1 Introduction

The penetrometer measurement resembles the process of mastication and ease of the first bite between the teeth. Although the results of penetrometer measurements can be related quite well to taste panel results, it is not clear which structural properties of the meat are evaluated. The penetrometer method can be used in combination with other instrumental tenderness methods raw or cooked meat, and can also be used for a wide variety of meat products.

5.2 Recommended Procedure

A cylindrical flat ended plunger (diameter 1.13 cm, area = 1 cm^2) is driven vertically 80% of the way through a 1 cm thick meat sample cut so that the fibre axis is perpendicular to the direction of the plunger penetration. The plunger is driven (100 mm/min) twice into the meat at each location and the work and force-deformation curves are recorded. The following parameters should be recorded:
Hardness: maximal force for first deformation (N).
Cohesiveness: ratio of Work done during the second penetration, relative to the first.
Gumminess: Hardness x Cohesiveness.
Although other parameters can also be defined (see Figure 3).

6. Conclusions

It is strongly recommended that the methods should be validated against sensory panels.

The reference methods are advanced as appropriate at this time but it is stressed that development of new techniques is likely as researchers explore mechanical properties of meat and the changes with handling procedures. The ideal of a single measurement to accurately predict consumer perceptions under all conditions may not be achievable.

7. References

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Figure 1. Shape and dimensions of template for tensile test specimens.
Figure 2. Typical Shear Force deformation curve for WB device.
Figure 3. Typical force deformation curve from penetrometer test.