ON-LINE ASSESSMENT OF MEAT TENDERNESS

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INTRODUCTION

The absence of an on-line method to measure meat properties has ensured that meat trading is still an art. An on-line method of measuring tenderness would identify good processors and optimal processing conditions and would ensure that the customer can rely on getting tender meat, but there are intrinsic difficulties in finding on-line measures of tenderness. Connective tissue is one contribution to toughness, it only varies slightly between sexes[1] and increases in non frying cuts as animals become older[2]. Connective tissue is not easily measured chemically, although it can be estimated by NIR[3] but it influences meat toughness by heat related collagen denaturation and shrinkage during cooking[4]. The breed and sex of animals have minor contributions, in spite of the disproportionate effort to relegate the interplay of different levels of calpains and calpastatins to this role[5,6]. The level of calpains, for example, are influenced by rigor mortis temperatures[7]

The visual appearance of meat gives little or no indication of its intrinsic quality and does not predict how it will be perceived by the consumer when it is eaten, either immediately or in the future. To some extent these problems have been overcome by ensuring that on-farm procedures and transportation to slaughter are controlled to reduce preslaughter stress and processing conditions are controlled[8] to ensure that rigor and subsequent ageing take place in a predictable way.

Near infrared spectroscopy (NIR) measurements to predict meat tenderness have been made[9,10,11], but a complete NIR system has not yet been developed. This may be because the ultimate tenderness is influenced by various physical factors that influence tenderness without affecting the NIR spectra. Alternatively the NIR spectra may be influenced by factors that are not related to tenderness such as light scattering or other physical phenomena. In this paper we look at meat with a wide range of tenderness values to provide additional information on the requirements for the development of suitable NIR methodologies to measure meat tenderness.

METHODS

Muscle (*longissimus thoracicum*, i.e. cube roll) was obtained from cows slaughtered at a processing plant that provides hot boned meat within 60 min of slaughter. The plants procedures involve head only electrical stunning (current limited to 2 A, 50 Hz, 4 seconds duration) followed by a cardiac arrest immobilisation current (2 A, 50 Hz) applied from brisket to head for 14 seconds and carcass electrical stimulation (14.3 square wave pulses per s at 10 ms duration at > 120 mA) applied for 40 seconds between the head and legs followed by normal carcass dressing procedures and hot boning. Muscle temperatures and pH falls were recorded on arrival at the laboratory and the rigor conditions were partially controlled by immersing the shrink wrapped muscle in water baths at 10°C. The use of electrical stimulation meant that rigor mortis occurred in approximately 4 hours and there was less control of rigor mortis temperature than was desirable. This resulted in a variation, albeit small, of the time of rigor entry which produced a variation of the initial tenderness values. There were four different collections, each obtaining a pair of muscles from 6 animals. Following rigor, the muscles were then aged at 6°C, 8°C and 10°C to provide a range of tenderness values over time. Samples of the muscle were removed for NIR analysis, using a NIRSystem 6500 scanning at 2 nm increments and a speed of 1.8 scans/s across a wavelength range 400-2500 nm in reflectance mode. Measurements commenced as soon after rigor as possible and this was repeated a number of times over the subsequent 14 days to get a range of tenderness values. Samples for shear force measurement were removed at the same time as NIR measurements and were frozen and held at -18°C. The frozen meat samples were cooked at 80°C for 1 hour. The shear force was measured on the chilled cooked samples from 1 cm x 1 cm slices using a MIRINZ tenderometer[12]. Because the muscles were hot boned, there was a possibility of shortening, the sarcomere length was measured over two of the collection periods[13] to determine if this had any effect.

RESULTS AND DISCUSSION

Hot boned meat collected at different times with slight differences in processing conditions produced a wide range of tenderness values (figure 1). The initial tenderness value depended on how quickly tenderness was measured after rigor mortis[14] and although the first samples for measurements were taken at approximately 5 hours, rigor was not identical for all samples for logistical reasons. In general, within each sample group, those samples that had a high shear force at the second readings (first reading was too variable between groups) did not become as tender after ageing as those that had a low shear force at the same time. The variability with the first reading suggested that ageing may not have progressed equally at this time. Within any collection period and set of plant conditions pertaining at the time, there was a high correlation of meat tenderness and NIR predicted tenderness ($r^2 = 0.873$) (figure 2). When several similar collection periods were combined, the correlation was lower with $r^2 = 0.71$. This suggested that there were variations in processing conditions that in some way were affecting tenderness without influencing the NIR spectra.

These processing differences can be illustrated in figure 3 where there is a clear range of sarcomere lengths that affects the tenderness within any group. The sarcomere length- tenderness relationships are not simple and influence ageing[15], as well as affecting perceived tenderness[16] Differences between different collections could be related to differences in processing and could thus be one reason for low correlations between groups. The initial differences in tenderness in figure 3, can be also be attributed to obtaining the meat at a different stages of ageing. Athough not the sole definitive explanation, this illustrates how the assessed tenderness is a sum of many

parameters. Other contributions such as collagen content can also be estimated by NIR[3] and may be a necessary to include in tenderness predictions.

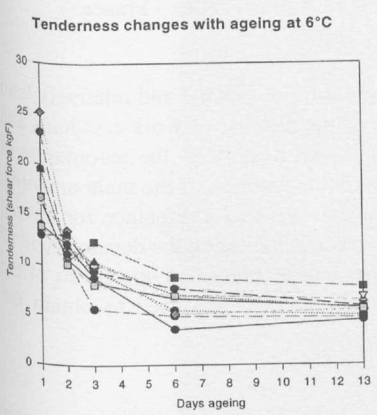

Figure 1. Tenderness changes over time for meat from which NIR spectra were obtained. These form the basis of the correlations used in figure 2.

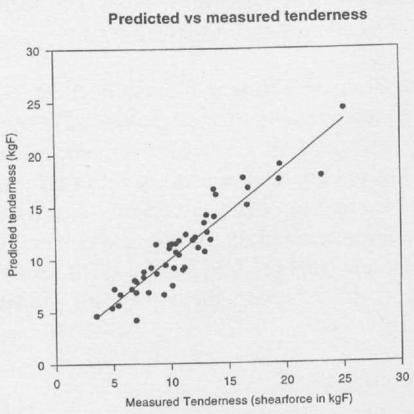

Figure 2. Tenderness data from one collection period (Fig.1) showing a high correlation (r^2= 0.873) of predicted vs measured tenderness

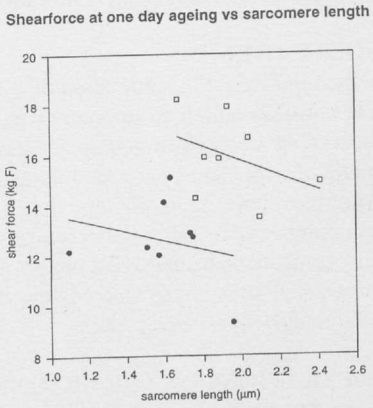

Figure 3. Data from two collections for which sarcomere lengths were also measured and correlated with initial tenderness values (i.e. unaged meat). Differences in ageing resulted in variations in initial tenderness.

Conclusions

The experiments show that NIR can give a estimate of meat tenderness for a standard processing condition. However, individual processing conditions differed subtly and generally in an unknown way and when experiments were combined, the correlation of NIR spectral components and meat tenderness was lower This suggests that the basic correlation is not a relationship between tenderness and NIR spectra *per se*, but is a measure of underlying processes that affect meat tenderness. In these experiments involving hot boning, profoundly affected by processing temperatures, we have identified structural components such as sarcomere length factors that affects tenderness without affecting the NIR pattern. The effect of these contributions needs to be understood to define a set of relationships that affect tenderness. If the relative contributions of these processes or any other variation, can be part of the calibration, it will be possible to measure NIR on-line.

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