MONITORING MEAT QUALITY

ERIC DRANSFIELD
AFRC, Institute of Food Research, Bristol Laboratory
Langford, Bristol, BS18 7DY, UK

SUMMARY: A method for monitoring rigor development was developed in which the normally suspended carcass is allowed to fall freely over a short distance (<50mm) onto a force transducer. After arresting the fall, the stiffness was assessed as the time taken to fall the fixed distance (drop time), the impact force on arresting the fall and the subsequent frequency of damped oscillations of the carcass which continued for up to 2 seconds. In the pre-rigor state, the leg hind bends during free fall to give a shorter drop time than that of a rigid body and also softening the impact and damping the subsequent oscillations. As the muscle becomes stiffer, the drop time, impact force and frequency therefore increase and approach those of a rigid body. The parameters, derived in pig, rabbit and chicken carcasses,.were correlated with the decline in pH and the increase in stiffness of the muscles in the hind leg, particularly the Tensor Fasciae Latae.

INTRODUCTION: The major determinant of quality is the rate at which rigor develops in the musculature. Muscles which go into rigor quickly whilst the meat is still warm, may develop pale, soft and exudative (PSE) meat which is particularly noticeable in about 10% of UK pigs (Chadwick & Kempster, 1983). The excessive amount of drip in such meat can be reduced by rapid cooling (Honikel, 1986). In beef and poultry, rapid rigor development leads to toughening due to rigor shortening.

When rigor development is slow, the meat may cool prior to rigor development and induce muscle (cold) shortening and lead to toughening in cooked meat (Dransfield & Lockyer, 1985). Although electrical stimulation has been successfully adopted to allow rapid cooling of beef and lamb carcasses, its has not been adopted generally for pig and chicken carcasses because of the fear of increasing rigor development and increasing the incidence of PSE meat.

Monitoring rigor development in individual carcases would allow optimal processing to minimise drip losses whilst avoiding toughening. A method for monitoring the process of rigor, suitable for on-line application, is developed and its commercial application is discussed.

EXPERIMENTAL

ANIMALS: Pigs (Large White and Pietrain) were stunned and slaughtered in a standard commercial fashion. Chickens were anaesthetized prior to bleeding and the carcass tested immediately. Rabbits were stunned, bled and skinned prior to measurement.

IMPACT TESTING: The carcasses (or sides) were suspended normally, from a pietzo-electric force transducer, by the Achilles tendon(s) on a gamble supported at the centre by an electro-magnet. When the magnet was switched off, the movement of the gamble activated a timer, and the carcass fell onto a rigid stop. The impact stopped the timer and the oscillatory forces were recorded for up to 2sec.

pH RECORDING: A 2g sample of *M Longissimus dorsi* (LD), *Semimembranosus* (Sm) or *Tensor Fasciae Latae* (TFL) was homogenised in 10ml of 5mM iodoacetate/150mM KCl (pH 7) buffer.

SKIN AND MUSCLE INVESTIGATIONS: The important muscle groups which determine the impact and oscillations was studied before and after cutting muscles in a rabbit carcass. In pigs, the importance of the skin was determined by skin removal from a side shortly after dressing and by following the changes in shape of the carcass as it fell using cinematography at about 1000 frames/sec.

EXTENSIBILITY IN ISOLATED TFL MUSCLE: The extensibility of TFL muscle was determined at 30°C by a cyclic tensile test. The muscle (approximately $1cm^2$ in cross-section and 4cm along the muscle fibre direction) was tied to the upper load cell and to a fixed base and immersed in liquid paraffin. The length of the muscle was recorded continuously during extension to $1.1N/cm^2$ and relaxation to $0.1N/cm^2$. The cyclic process was repeated continually and the extensibility determined as the ratio of length at the upper stress to that at the lower stress.

RESULTS: When the carcass was hanging stationary on the gamble the force on the transducer is caused only by the weight of the carcass (extreme left of Figure 1). As the carcass is released and is falling freely the output from the transducer falls rapidly to zero. When the carcass and gamble are arrested by a lower stop, the force increases rapidly at the point of impact and subsequently oscillates about the weight of the carcass. The oscillations gradually decreased and when completed (2sec), the transducer records a value equal to that of the weight of the carcass.

T-77

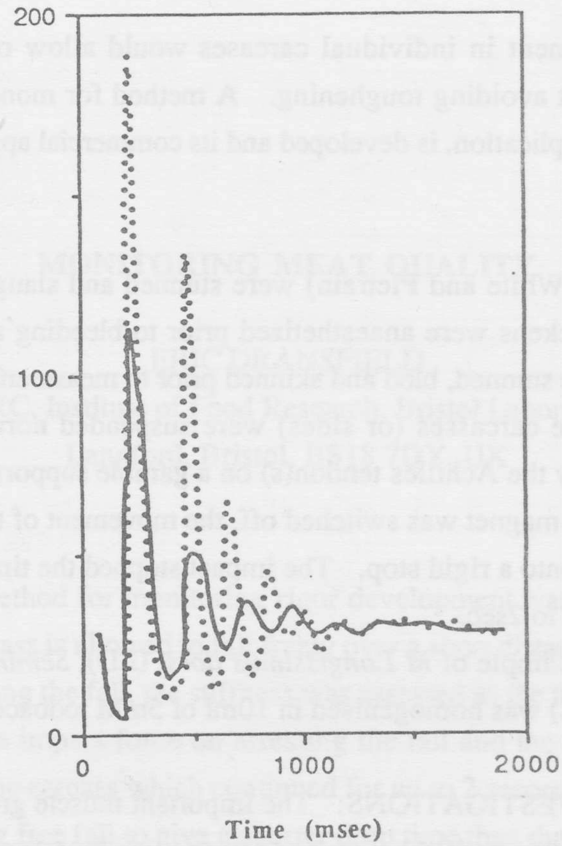

Figure 1 Impact and oscillatory forces following a drop of pig carcass

Time course of oscillation in, pre-(solid line) and post-rigor (dotted line) carcass.

The first parameter (drop time) was the time taken from release of the carcass to the maximum first peak force and, in a pre-rigor pig carcass falling through 50mm, is about 70msec. The second was the maximum impact force and the third was the frequency of the oscillations after the first peak. In the post-rigor carcass, the drop time was longer and the peak force and the frequency were higher than in the pre-rigor carcass (Figure 1).

The oscillations were analysed by Fourier transformation to produce a frequency spectrum. In the chicken carcass (Figure 2), the major component of the oscillation was at about 2Hz and arose from a pendular movement of the whole carcass. The major frequency resulting from the internal movement of the carcass was at about 10Hz. This frequency increased to about 22Hz at 3hours after slaughter (Figure 3). Similar curves were found for carcasses of 1.6 to 3.6kg. In pig carcasses the frequency increased from 13Hz to 22Hz at about 5hours. This lower rise in frequency would be expected from the lower rate of rigor development in pigs than in chicken. In rabbit carcasses, the frequency increased from about 13Hz to 22Hz after 3-4 hours (Figure 4). When the attachments of TFL muscle was severed, the frequency was reduced to less than that in the pre-rigor carcass demonstrating that this muscle was important in determining the stiffness using this technique.

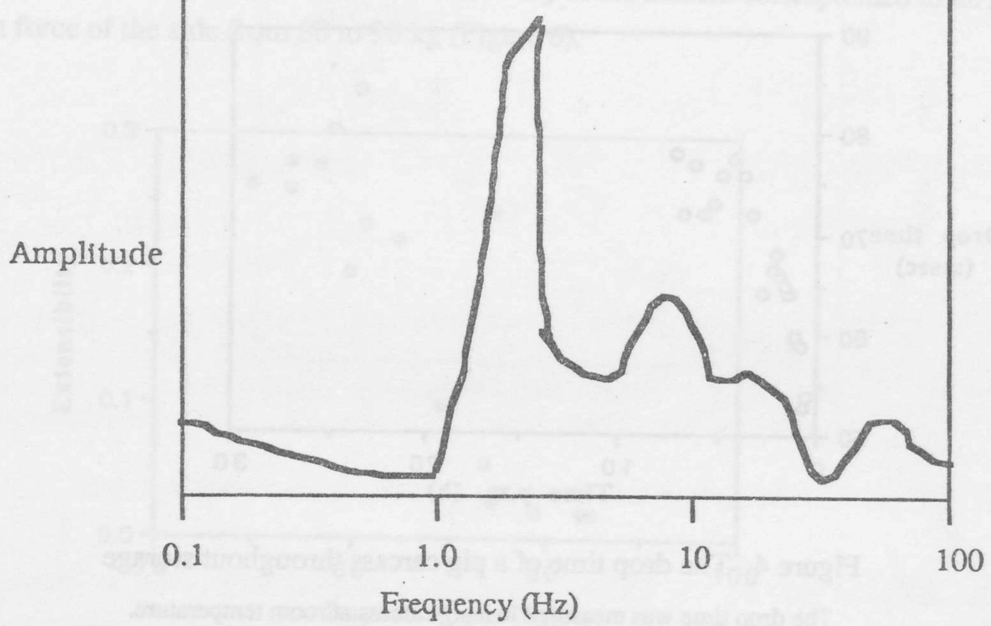

Figure 2 Frequency spectrum of oscillations following an impact given to a chicken carcass

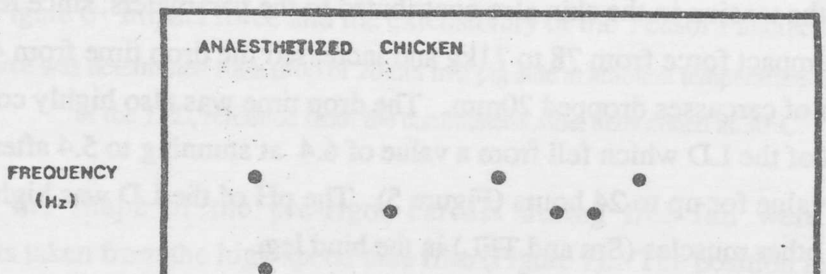

Figure 3 Frequency of oscillation after stunning in chicken carcasses

The major frequency of oscillation was measured at times up to 6 hours after stunning in 3 carcasses of the weights given.

In pig carcasses falling 50mm (Figure 4) the drop time increased from about 55msec soon after slaughter to 85msec reaching a plateau before 24 hours.

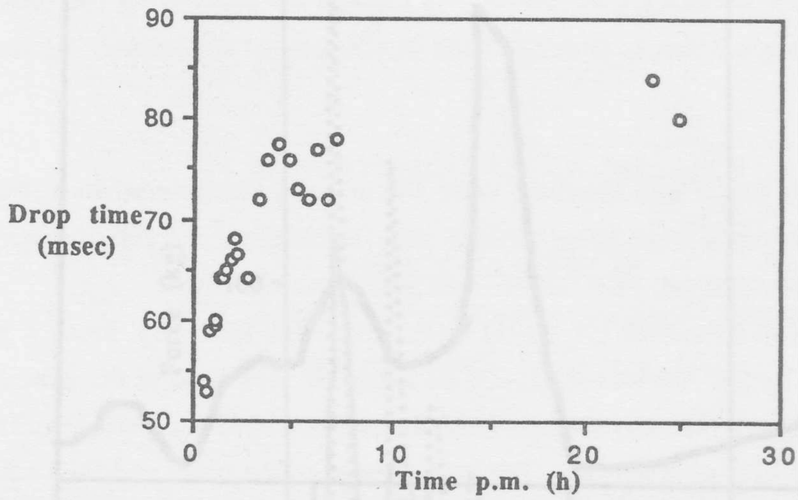

Figure 4 The drop time of a pig carcass throughout storage

The drop time was measured in a pig carcass at room temperature.

In pig carcasses, the tension in the skin also contributed to the parameters, since removal of the skin reduced the impact force from 78 to 71kg and increased the drop time from 48 to 52msec in 10 paired sides of carcasses dropped 20mm. The drop time was also highly correlated with the decline in pH of the LD which fell from a value of 6.4 at stunning to 5.4 after 8 hours and remained at this value for up to 24 hours (Figure 5). The pH of the LD was highly correlated ($r>0.9$) with two other muscles (Sm and TFL) in the hind leg.

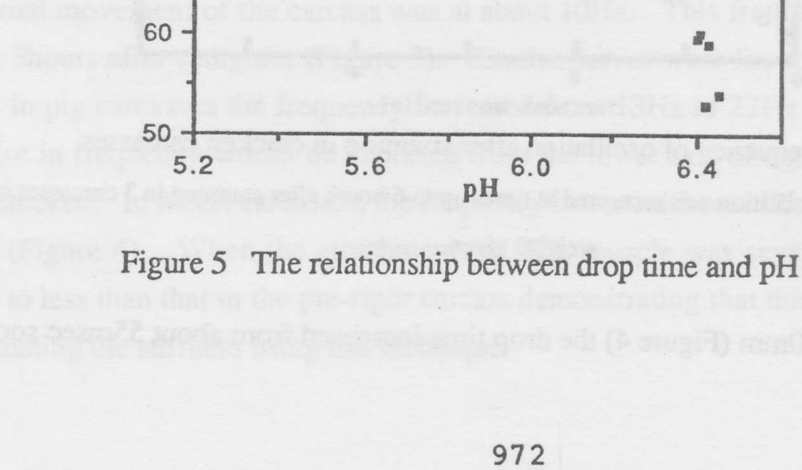

Figure 5 The relationship between drop time and pH in pig LD

Extensibility was about 28% in excised pre-rigor pig TFL and decreased to a minimum of about 2% when in full rigor. This decrease in extensibility of the muscle corresponded to an increase in impact force of the side from 80 to 90 kg (Figure 6).

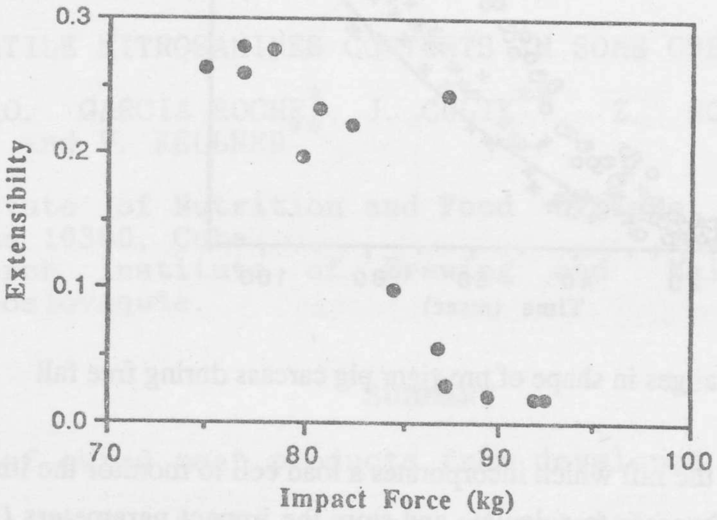

Figure 6 Impact force and the extensibility of the Tensor Fasciae Latae
The impact force was determined for a drop of 20mm in a pig side at ambient temperature and the extensibility of the TFL, removed from the contralateral side, determined at 30°C.

Changes in the shape of the pre-rigor carcass during free fall were followed from measurements taken from the high speed cine film (Figure 7). The position in the centre of the back (+) took about 60msec to fall 20mm and 100msec to fall 50mm. This is similar to that expected for the fall of a rigid body which is represented by the solid line. The position of the point of suspension (Achilles tendon, o), however fell 20mm in only 43msec and 50mm in only 70msec. Therefore, during free fall, the pre-rigor muscles and skin tended to pull the lower part of the hind leg donwards, back into a more natural (bent) posture. In the post-rigor carcass, little change in shape took place during free fall.

DISCUSSION: The method provides a simple way of monitoring the development of rigor in carcasses by allowing the carcass to fall a fixed distance onto a rigid support and as such should be readily applicable to on-line monitoring.
The advantages of the novel system described here is that is inexpensive, not manually operated and requires little maintenance or calibration. The method is suitable for installation in the commercial slaughter line, and a prototype monitoring station has been installed in the abattoir at Langford. The rail used to suspend the carcasses was modified to incorporate a ramp along which the carcasses rise by about 20mm. The necessary impact conditions are produced as

J-79

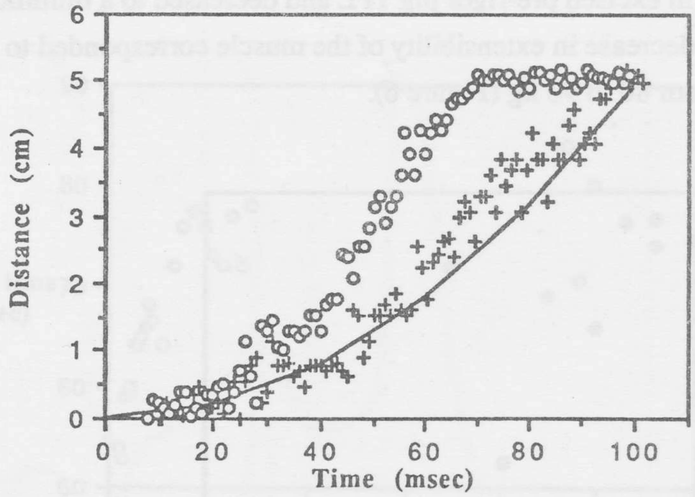

Figure 7 Changes in shape of pre-rigor pig carcass during free fall

the carcass falls back onto the rail which incorporates a load cell to monitor the impact forces and is linked to a microprocessor to calculate and store the impact parameters (Dransfield, 1989).

Monitoring rigor development may be used in combination with electrical stimulation to optimize a single processing system. For each carcass individually, the extent of rigor development would be measured and the appropriate amount of stimulation given to each carcass to achieve a common state of rigor development. These carcasses can be processed in the same way and allow rapid cooling without quality deterioration and reduce evaporative and drip losses.

REFERENCES:

- Chadwick, J.P. and Kempster, A.J.(1983). *Meat Sci.*, 9: 101.
- Dransfield, E. and Lockyer, D K. (1985). *Meat Sci.*, 13: 19.
- Dransfield, E. (1989). UK Patent Application Number 8908720.9
- Honikel, K.O. (1986) *Recent advances and developments in the refrigeration of meat by chilling*, International Institute of Refrigeration, Bristol.