THE INFLUENCE OF END-POINT COOKING TEMPERATURE ON SHEAR FORCE MEASUREMENTS

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Introduction

The way meat is cooked influences its palatability, hence for objective testing and to allow comparisons, we need to standardise the method of cooking. Tenderness (a consumer derived measurement) is determined by feeding cooked meat to consumers, whereas shear force is an objective measurement on a cooked piece of meat obtained from an instrument. The methods for preparing meat for shear force assessment have been widely varied; it may be cooked from fresh (AMSA,1995) or from the frozen state (Graafhuis *et al.*, 1991; Duckett *et al.*, 1998) or thawed for an indeterminate time (often overnight) before cooking (Locker and Daines, 1973; Jeremiah *et al.*, 1991; Ferguson *et al.*, 2000). In addition, there are variations in the end-point temperature to which meat is cooked, ranging from 65-80°C, with significant differences in tenderness between the lowest and highest temperatures (Graafhuis *et al.*, 1991; Bejerholm and Aaslyng, 2004), or meat may be cooked for a defined period of time at a given temperature (Ferguson *et al.*, 2000). Even if meat samples are cooked to the same end-point temperatures, using a different heating temperature (e.g. 160°C or 100°C) will result in vastly different temperature profiles from outside to the interior (Bejerholm and Aaslyng, 2004) creating layers at different degrees of doneness. Adding to the problem further is that many different cooking methods have also been used including contact frying, hot air roasting, radioactive grilling, liquid immersion and even microwaves.

As meat ages, the cytoskeletal proteins degrade and the contribution of these compounds diminishes with none being present in fully aged meat. Thus it would be expected that cooking temperature effects may differ for aged and non-aged meat. Actin degradation in the range 70-80°C is another influencing factor and hence end-point temperatures should be kept as consistent as possible and under or overshooting should be minimised.

The present experiments investigate the effect of cooking meat to four end-point temperatures from 65-80°C over a three-day period of ageing at 15°C. The chosen temperature range covered the likely end-point temperatures encountered, especially if the meat is not removed from the heating medium before there is an overshoot.

Materials and Methods

Eight *m. longissimus lumborum* from bulls that were electrically stunned and not electrically stimulated were obtained from an abattoir undertaking hot boning. The muscles were immediately transported to a laboratory and within 90min from slaughter were wrapped tightly in polyethylene film and held at 15°C to go into *rigor mortis* (pH values at *rigor mortis* ranged from 5.5-5.7). For convenience, the muscles were taken to a 4°C room and held overnight to reduce the rate of ageing. The next day the muscles were placed in a 15°C room to equilibrate and age at this temperature.

After 12, 24 and 48 hours of ageing, samples were taken from each muscle and were cooked in the following manner: From each muscle, four 30 mm thick slices (~250 g) were obtained and thermocouples placed into the centre of the muscles. The four samples were placed in weighted plastic bags and placed in an 85°C water bath. The temperatures were closely monitored so that when the first piece of meat reached 65°C, it was immediately removed and placed in ice water; this was repeated as the remaining meat samples reached 70, 75 and 80°C respectively. The cooking procedure was then repeated for each of the eight muscles at each of the ageing times. Every cooked sample was then cut along the muscle fibre axis using scalpel blades to produce at least six sub samples (termed bites) with a 1cm x 1cm cross section. Each bite was sheared using a MIRINZ tenderometer with a wedged shaped tooth (as described by Graafhuis *et al.*, 1991) and the peak shear force value was obtained. The entire experimental procedure gave shear force values at four cooking temperatures with eight *m. longissimus lumborum* samples aged for 3 different times.

Results and Discussion

It took approximately 13 minutes for the meat to reach 65°C and 20 minutes for the meat to reach the 80°C end-point temperature. In order to avoid an overshoot, the samples were removed from the water bath early so that the measured end-point temperature was as close as possible to the nominal value. Most measured end-point temperatures were within ± 1°C of the nominal value.

There was a wide variation in shear force values at all end-point temperatures, as shown by the standard error bars in Figures 1A and 1B. End-point temperature had the biggest impact on shear force values from meat aged for 12 and 24 hours, with much less impact after 48 hours of ageing (Figure 1A). Figure 1B showed significant differences between

meat cooked to 65, 75 and 80°C ($p < 0.01$) after 12 hours of ageing, but no significant differences between the different end-point temperatures after 24 and 48 hours of ageing.

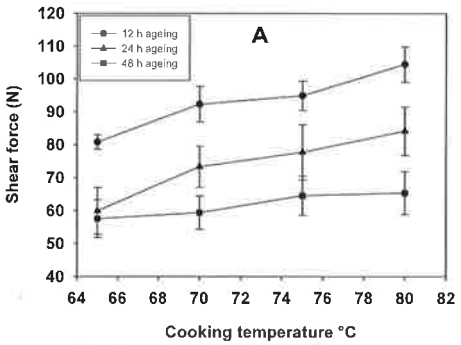

Figure 1A: The effect of ageing duration on the shear force values of meat cooked to various end-point temperatures.

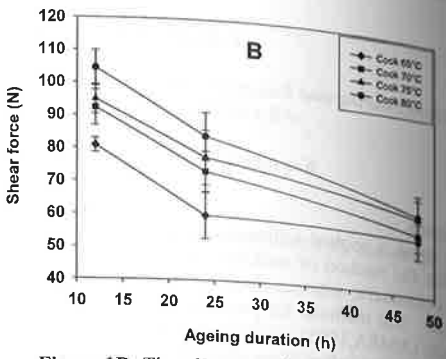

Figure 1B: The effect of end-point cooking temperature on the shear force values at three different ageing durations.

Analysis of the mean values showed that there was an average increase of 1.6N per degree for the range 65 to 80°C at 12 hours ageing, which reduces to 0.7N per degree for 24 hours ageing and 0.2N per degree for 48 hours ageing. Hence, at a nominal end-point temperature, a 5°C overshoot will result in mean shear force values that differ by about 8N for meat aged at 15°C for 12 hours. The differences in N in this instance are greater than the standard deviation of the bites of each meat sample where the range at 12h ageing is 24N.

Conclusions

Although an increase in the mean shear force values was observed for higher end-point cooking temperatures, increases for individual readings were generally obscured by the variation in shear force measurement. The end-point temperature only had a significant impact at the shortest ageing duration of 12 hours at 15°C. After longer ageing periods, the end-point temperature had no significant impact on shear force values.

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