INFLUENCE OF PRE-COOK MUSCLE TEMPERATURE ON THE OBJECTIVE EVALUATION OF MEAT QUALITY

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Summary

Several workers have reported an effect of pre-cook muscle temperature on tenderness of the cooked steak. In addition, research guidelines recommend that laboratory procedures standardise pre-cook muscle temperature. Two experiments were conducted to determine the magnitude of this effect.

Experiment 1. Striploins were collected from stimulated carcasses. Steaks were cut (22 mm thick) from striploin aged for 7 days at 4°C and frozen at -20°C. Steaks were thawed at 4°C for 48 hours and cores cut (56mm diameter) and conditioned 1°C, 10°C, 20°C, and 30°C for 1 hour in a water bath, prior to grilling to an internal temperature of 70°C. Tenderness was assessed using shear force and compression. Results showed no effect of pre-cook temperature on shear force, compression measurements or cooking loss percentage ($P>0.05$).

Experiment 2. Unaged striploins from stimulated carcasses were frozen at -20° C and then thawed at 4°C for 48 hours. Blocks were cut (250 g), prior to conditioning in a water bath at 1 and 30°C for 1 hour. Blocks were then cooked at 70°C in a water bath for 1 hour. Results showed a small decline in shear force with an increase in pre-cook temperature (0.01 kg/°C, $P<0.05$).

It was concluded that in meat samples from stimulated carcasses, pre-cook temperature did not affect objective tenderness in steaks cooked to a constant temperature, whilst there was a minor effect on objective tenderness in blocks cooked for a set time.

Introduction

A number of studies have investigated the effect of a wide range of pre-cook temperatures on tenderness of cooked meat. The results from Moody *et al.* (1978), Hostetler *et al.* (1982), Berry and Leddy (1990) and Wheeler *et al.* (1996) have shown that an increase in pre-cook temperature (range 2 to 26°C) resulted in a decrease in tenderness, although the magnitude of the decline was variable. Vial *et al.* (1943) did not show any advantage of thawing beef steaks to either room or refrigerator temperature, but did show an increase in toughness of steaks thawed at oven temperatures. The possibility of an effect of pre-conditioning temperature of meat on tenderness has been incorporated into the research guidelines for meat quality evaluation, published by the American Meat Science Association, where they recommend that steaks, chops, patties and roasts should be thawed at 2.5°C until the internal temperature reaches 2.5°C (Anon, 1995).

The possibility of a pre-cook temperature effect on tenderness of meat may have commercial implications which could be captured by new cooking technology, but as also recognised by the American Meat Science Association (Anon 1995), it may also have implications in the standardisation of laboratory methodology. This study investigated the effect of pre-cooking temperature on meat tenderness in two experiments. Firstly cooking steaks using a similar protocols to previous studies which had reported the effect, and secondly, on blocks of meat prepared using our standard laboratory protocol for the objective evaluation of meat.

Materials and Methods

Experiment 1 used striploin steaks from 7 grain fed heifers which were effectively stimulated at slaughter (low voltage rectal-nostril stimulator, peak voltage 45 volts, 200 milli-amps, 40 seconds duration). Striploins were aged at 4°C for 7 days prior to cutting into steaks (10 steaks from each loin, each 25 mm thick) and freezing at -20°C for a further 7 days. Steaks were thawed at 4°C for 48 hours and a central core taken (55 mm diameter). Cores were placed in plastic bags and immersed in water baths held at either 1°C, 10°C, 20°C, or 30°C for 1 hour. Individual cores were then inserted with thermocouples prior to cooking in a vertical griller to an internal temperature of 70°C. The cores were allowed to cool at room temperature for 1 hour prior to cutting 5 rectangular slices (150 x 66 mm) parallel to fibre orientation for modified Warner Bratzler shear determinations (Bouton *et al.* 1975). Two wedges (15 mm high) were cut from the remaining core for measuring compression.

Experiment 2 assessed the effect of pre-cook muscle temperature using the experimental protocols of the Meat Quality CRC Progeny Evaluation program which were essentially the same as those detailed by Bouton *et al.* (1975). Striploin samples were obtained from 7 grain fed steer carcasses which were stimulated using a low voltage system (parameters as previously described). Striploins was removed from the carcass approximately 20 hours after slaughter, vacuum packaged, and frozen at -20°C for 7 days. Striploins were thawed at 4°C for 48 hours and 2, 250 gram rectangular blocks cut from each loin. Within loin, blocks were conditioned in a water bath at either 1°C or 30°C for 1 hour, prior to cooking in a water bath at 70°C for 1 hour and cooled in cold running water for 30 minutes. Rectangular strips for the shear test and wedges for the compression test were cut and measured as before.

Analysis for both experiments used a mixed model where pre-cook temperature treatment was a fixed effect and loin was treated as a random effect.

Results and Discussion

In experiment 1, pre-cook temperature had no effect on shear force compression measurements or cooking loss percentage ($P>0.05$). Grilling time decreased from 18.5 to 14.7 minutes as pre-cook temperature increased from 1°C to 30°C. Hostetler *et al* (1982) demonstrated that a 10°C increase in meat temperature between 2 and 26°C resulted in a reduction in cooking time by 4.6 minutes. Raising the internal temperatures of steaks from 4.1°C to 10.5°C, Berry and Leddy (1990) found cooking time decreased from 9.1 minutes to 8.4 minutes per 100 grams. Similarly, Wheeler *et al.* (1996) showed a 4.8 minute decrease in cooking time for steaks held at 6°C, compared with 12°C prior to cooking.

In the second experiment, there was a significant decrease ($P<0.05$) in shear force as pre-cook temperature increased from 1°C to 30°C. Assuming a linear change, the difference between the temperatures suggested that for each 10°C increase in pre-cook temperature, there was

0.13 kg fall in shear force. Interestingly, there was no change in compression measurements ($P>0.05$), which suggests that the effect may have been largely via the myofibrillar component. Wheeler *et al.* (1996) commented that the effect of pre-cook temperatures may be mediated through increased protein hardening. Although not measured in this experiment the meat held at pre-cook temperatures of 30°C would have certainly reached an equilibrium temperature faster during cooking and would have been held at that temperature for a longer time than the meat held at a pre-cook temperature of 1°C. Cooking loss also remained unaffected by the pre-cook temperature.

Table 1 Predicted means and standard errors for the effect of pre-cook muscle temperature on objective measurements in Experiments 1 and 2

Dependent Variables	Experiment 1 (cores grilled to 70°C constant internal temperature)					Experiment 2 (blocks cooked in a water bath at 70°C for a 1 hour)		
	Pre-cook temperature				Average se	Pre-cook temperature		Average se
	1°C	10°C	20°C	30°C		1°C	30°C	
Peak Force (kg)	3.63	3.85	3.44	3.69	0.19	3.58[c]	3.19[d]	0.16
Compression (kg)	1.02	1.20	0.95	0.90	0.10	1.15	1.14	0.05
Cook Loss (%)	0.17	0.17	0.17	0.17	0.01	0.23	0.22	0.00
Grill Time (min)	18.53[a]	16.56[b]	15.56[c]	14.72[d]	0.25			

a, b, c, d within experiments means in the same row with different subscripts are different ($P<0.05$).

The results from these two experiments indicate that there was either no effect, or only a small differences in objective tenderness measurements when samples from stimulated carcasses were held at different pre-cook temperatures and cooked to either a set internal temperature, or for a set time. This outcome is in contrast to the results of Hostetler *et al.* (1982) who found that an increase of 24°C (2 to 26°C) reduced shear force by 2.7 kg. Hostetler *et al.* (1982) stated that the demonstrated decrease in shear force would be sufficient to be detected by a sensory panel. In experiment 2, the 0.39 kg decrease in shear force over the 1°C to 30°C temperature range was of a smaller magnitude to that reported by Moody *et al.* (1978) and Berry and Leddy (1990). The experiment of Moody *et al* (1978) established that a temperature increase from 3.3°C to room temperature caused a 0.8 kg decrease in the shear force. More recently Wheeler *et al.* (1996) reported that there was a 0.67 decrease in shear force in samples from unstimulated carcasses which had pre-cook temperatures of 6 and 12°C resulted in a 0.67 decrease in shear force. With the exception of Vial *et al.* (1943), who reported no effect of pre-cook temperature on tenderness, these results from the above studies indicate a much greater effect of pre-cook temperature on tenderness than found in our study. It is difficult to suggest a mechanism which would give rise to all of the variation in results between studies. It is possible that the differences may have been mediated by increased ageing in the pre-cook period, particularly in samples from unstimulated compared with stimulated carcasses. Often information on stimulation status was not available from the earlier studies (Vial *et al.* 1943, Moody *et al.* 1978 and Berry and Leddy 1990), or in the case of Hostetler *et al.* (1982) they found no interaction between stimulation and pre-cook temperature. Certainly in the more recent study of Wheeler *et al.* (1996) carcasses were not stimulated. In our study the stimulated carcasses would have gone into rigor at higher temperatures than normal and it is possible that the calcium dependent proteases may have been autolysed under the elevated rigor temperatures to limit ageing (Simmons *et al.* 1996). In our study samples which were frozen 24 hours post-slaughter showed only a small decrease in shear force for a very large increase in pre-cook temperature, whereas samples which had been aged for 7 days at 4°C showed no change in peak force or compression measurements.

Conclusions

The magnitude of the change in either peak force, or compression resulting from a wide range of pre-cook temperatures in both experiments was very small and would be unlikely to be detected by consumers. However, the potential influence of the effect dictates that the uniformity of pre-cook muscle temperature is a factor which should be considered in the design of protocols for meat quality evaluation, although in stimulated carcasses the effect appears to be very small.

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