OHMIC COOKING OF NON COMMINUTED BEEF *BICEPS FEMORIS*

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Introduction

Ohmic heating is a thermal process which occurs when an electrical current is passed directly through a food and the resistance imposed by the food leads to the generation of heat within the product. The basic principles as well as the factors influencing ohmic cooking have been explained by Sastry (1994) and Ruan (2004). Sastry and Palaniappan (1992) and Fryer *et al.*, (1993) reported that ohmic heating can be used in a continuous flow mode to cook and sterilize liquid food and solid-liquid mixtures. Nowadays ohmic heating is viewed as an alternative heating system for pumpable foods and there are currently a number of commercial scale processing plants in various countries (UK, Italy, Mexico) producing fruit and/or vegetables in sauces and also pasteurised orange juice and liquid egg. While a number of the early patents in ohmic heating of meat were in the area of meat processing the amount of in-depth research conducted to date has been quite limited in spite of the fact that ohmic heating has the potential to cook meat in a much shorter time than the conventional cooking procedures. Shirsat *et al.*, (2004) and Piette *et al.*, (2004) showed that it is possible to cook comminuted meat emulsions ohmically to a comparable quality to conventional cooked samples. However, these products represent a relatively small proportion of total cooked meats and no results have yet been presented on the quality of ohmically cooked non comminuted meats. Lyng and McKenna (2006) discussed the differences between non comminuted and comminuted meats in the context of ohmic heating. The ohmic method requires uniform conductivity values within the meat which means that a perfectly even distribution of injected salt or brine solutions must be achieved in the case of non-comminuted meats. The aim of the current research is to compare selected quality attributes of conventionally and ohmically cooked entire non-comminuted whole muscle meat cooked to similar cook values.

Materials and Methods

Muscle: High quality single muscle beef *biceps femoris* was purchased from a local supplier (Kepak, Clonee, Co. Dublin, Ireland). This muscle was selected primarily because of its uniform myofibrillar structure.

Meat preparation: Six uniform pieces of *biceps femoris* (146 g) were prepared to incorporate a specified amount of a 3% salt solution. After injection the meat was tumbled at 4°C in a vacuum tumbler.

Cooking equipment: For ohmic cooking the tumbled meat was filled into a casing which was placed in a cylindrical stainless steel cell (length 0.075 m and internal diameter 0.073 m). The cell was lined with Teflon tape and insulated. The ends of the cell were fitted with plastic caps within which platinum-coated titanium electrodes (0.069 m diameter) were housed. The casing was left open at the ends to ensure direct contact between the electrodes and the meat. Temperatures were measured with a multi thermocouple probe (with one thermocouple located in the geometric centre and the other near to the surface) and monitored at 1 s intervals with a data logger. The meat pieces were cooked with a 3.5 kW (15 A, 0-240 V, 50 Hz) batch ohmic heater at a constant voltage-density of 12.5 V/cm. The electrodes were spring-loaded to ensure optimal contact between the meat and the electrode surface. Reference meat samples were cooked conventionally in a thermostatically controlled steam oven set at 80°C. Internal product temperatures were recorded at 30 s intervals using a Type K thermocouple (placed at the geometric centre of the product) and a data logger. The product was cooked until an endpoint temperature (coldest spot) of 72°C was reached and this was followed by a 2 min holding time. Cook values (C_s) were subsequently calculated (Lyng and McKenna, 2006) from this time temperature data. In order to reach similar C_s values between ohmic and steam cooking, preliminary experiments showed that a combined pre heat and hold interval amounting to a maximum of 12 min was required. Pasteurisation units were also calculated using equations given in Lyng and McKenna (2006). For the cooling process all samples were cooled for 1 h in a circulating water bath (8°C) followed by 24 h cooling in a refrigerator (4°C).

Quality assessment: The cook loss was determined by measuring the difference between the fresh and cooked weights and dividing by the fresh weight. Total salt content was analyzed using the method of Fox (1963). Hunter L*a*b* values were measured using a Minolta colorimeter and Hue angle (H) and Chroma (S) were calculated using equations given in Shirsat *et al.*, (2004). Colour readings were taken at six different points in the centre area of the cooked meats. For Warner Bratzler (WB) shear force measurements 10 strips 3 cm long and 1×1 cm in section were prepared by cutting the meat in the plane perpendicular to the direction of the fibre bundles. Maximum shear force (N) was recorded by an Instron universal testing machine following meat pre-equilibration at 25°C with the blade cutting the slices at right angles to the fibre direction.

Statistical analysis: Warner Bratzler shear force, salt content, cook loss and colour were analysed by ANOVA.

Results and Discussion

Significantly shorter cooking times were required in ohmic vs. conventional heating to produce similar C_s values (12 vs. 36 min respectively). With the ohmic process meat was heated to its final temperature in 65 s. The main problem that appeared was the heat loss which occurred in regions of the product adjacent to the outer surfaces. So a cook time that ensured these regions were heated to the target temperature (72-74°C) for times that gave similar C_s values to steam-cooked meat led to core temperatures of 80-84°C. From steam cooked products the range from core to the outside of the product was approximately 6°C. Cook values of 3.82 and 3.99 were reached for the ohmic and conventional cold spots respectively though a value of 6.63 was reached in the hottest region of the ohmically heated samples. This data is shown in Figure 1. Pasteurisation units calculated from the time temperature profiles showed values of 2800 for ohmic vs. 1480 for steam cold spots indicating the ohmic process would have induced approximately double the amount of kill of the reference microorganism used in pasteurisation unit calculation. Cook loss was lower in ohmic samples which also had significantly higher L* and lower a* values (p<0.05) indicating a lighter, less red meat and this difference was also visible to the naked eye. In relation to tenderness ohmic heated samples were tougher (P<0.05) though the difference was only 5.08 N (Table 1) which is unlikely to be detected by a sensory panel. Furthermore, the centre regions of the ohmic samples were heated to higher temperatures to compensate for the heat loss from the outer regions and therefore definite conclusions on texture cannot be made until this surface cooling problem can be resolved.

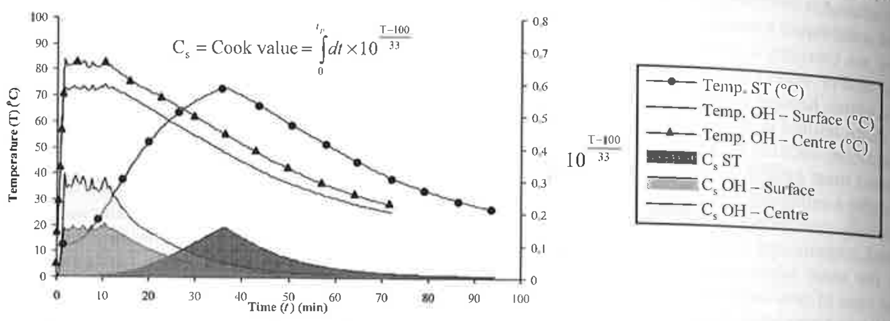

Figure 1: Time temperature and time cook value (C_s) profiles for ohmically (OH) and steam (ST) cooked beef *biceps femoris*.

Table 1: Quality parameters of ohmic and steam cooked whole beef *biceps femoris*.

	Salt (%)	WB (N)	Cook loss (%)	L*	a*	b*	H	S
Ohmic	1.16	52.48^a	27.7^b	59.62^a	2.37^b	10.09	76.61^a	10.38
Steam	1.15	47.40^b	37.9^a	55.80^b	2.79^a	10.07	74.47^b	10.46

[a,b] means in a column with different superscript letters are significantly different (P<0.05)

Conclusions

The results show that it is possible to ohmically cook injected whole muscle (*biceps femoris*) beef to produce lower cook losses and levels of quality which are comparable to those achieved by conventional methods. Additional research is needed to eliminate local temperature variations caused by heat loss.

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