THE EFFECT OF RADIO FREQUENCY POWER ON TEMPERING TIMES AND TEMPERATURES IN BEEF BLENDS OF VARYING COMPOSITION

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Introduction

Radio frequency (RF) is an emerging electroheating technique which has potential to reduce cooking times (Rowley, 2001). When used for heating solids it differs from conventional heating where heat is transferred through the product from the outside to the centre primarily by conduction, resulting in a temperature differential between the edge and centre. In contrast, RF heating involves the application of a high voltage alternating electromagnetic field to a product placed between two electrodes where volumetric heating takes place, primarily by an ionic depolarisation mechanism (Zhang *et al.*, 2004). Since the late 1980s RF heating has achieved some commercial success in the area of post bake drying of cookies and snack foods (Mermelstein, 1998). There have also been a number of recent publications in the area of RF pasteurisation of meat products (Zhang *et al.*, 2004; Brunton *et al.*, 2005). Research in the area of RF defrosting of meat has focused on thawing and not tempering and has been relatively limited in comparison to research in other areas. Early RF thawing applications were proposed for eggs, fruits, vegetables, fish and meat (Cathcart *et al*, 1947). Jason and Sanders (1962) thawed fish using an RF unit at a frequency range from 36 to 40 MHz, and their results showed a significant reduction in thawing time and quality improvement as less drip was observed. Sanders (1966) and Bengtsson (1963) also reported reduced thawing times with the former author also claiming lower drip loss. The objective of the present study was to develop an RF tempering protocol and to evaluate temperature distribution in a range of beef blends during conventional and RF tempering. Specifically, the purpose of the tempering was to heat the product from the storage temperature of -18°C to a temperature range of -2 to -5°C where it can be processed mechanically.

Materials and Methods

Meat handling and preparation

Beef lean (95% visual lean) and fat was purchased from a local supplier. The lean and fat were ground through a 10 mm plate using a mechanical mincer and subsequently bowl chopped for 3 minutes. A 50:50 mixture was prepared by bowl chopping an equal amount of lean and fat for 3 min. Thirty boxes (20×20×10 cm) were prepared using freezer grade cardboard (0.3 cm thick) and equal numbers were filled with lean, fat or 50:50 mixture. Care was taken to exclude air inclusion during box filling and then the meat surface was covered with a cellophane film. Boxes were frozen for 48 hour at -20°C and subsequently predrilled at specified locations to facilitate temperature measurement.

RF and conventional tempering

An RF oven consisting of a low power RF generator (600W) with a complimentary automatic impedance matching network and controller at 27.12 MHz was used to temper the blocks of meat. The box was placed at the centre of the lower electrode and tempered using the time/power combinations summarised in Table 1. Conventional tempering procedures were developed using a refrigerated incubator, programmed to mimic industrial methods. The target temperature range was -2 to -5°C.

Temperature measurement following RF and conventional tempering

A time temperature logger was used to record post tempering temperatures at fifteen specified points within the product using a thermocouple jig fitted with Type K thermocouples.

Results and Discussion

There was a large reduction in tempering time using RF compared to the conventional method. With the latter the average time to reach the target temperature range was 335, 348 and 391 min for lean, fat and 50:50 mixture respectively. By contrast in the case of lean beef, RF achieved target temperatures in 11-12 min (400W), 10-11 min (500W) and 9-10 min (600W). Corresponding times for the mixture were 13, 12 and 11 min for 400, 500 and 600 W respectively. However, with fat alone the target range could not be achieved without runaway heating developing within the sample at any power level.

The overall mean temperatures at the end of RF (using 600 W as an example) and conventional tempering are compared in Figure 1. As seen in the Figure there was a greater temperature range within RF heated products with a high fat content making the greatest contribution to the observed effect.

Table 1: RF time/power combinations used.

Meat type	Power (W)	T1 (min)	T2 (min)	T3 (min)	T4 (min)
Lean	400	9	10	11	12
	500	8	9	10	11
	600	7	8	9	10
50:50 Mixture	400	10	11	12	13
	500	9	10	11	12
	600	8	9	10	11
Fat	200	14	18	-	-
	400	10	11	-	-
	500	8	9	10	-
	600	8	-	-	-

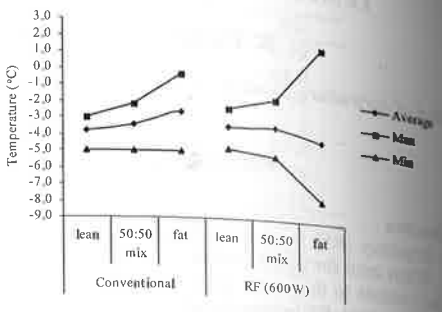

Figure 1: Post tempering temperatures[1].

As expected for conventional tempering the coldest spot was located at the geometric centre of the samples. In contrast, for RF tempering the geometric centre was the warmest spot for both lean and 50:50 mixture, though for fat the top surface was the warmest area.

With lean meat tempered by RF, the temperature at the power settings used ranged between -2 to -5°C while for the 50:50 mixture the range at similar power settings (-1.8 to -5.5°C) was slightly outside the target. However, for fat the range was much wider (*e.g.* at 600W for 8 min, temperatures ranged from +1.7 to –7.7 °C (Figure 1))

It is clear that for the RF oven configuration used, high fat levels had a major negative effect on tempering resulting in increased treatment time and less uniform temperature distribution.

Conclusion

The current study shows that the RF tempering protocol developed was successful for tempering lean beef and a 50:50 lean/fat mixture though the latter was on the temperature limits of the target range chosen. With the current setup the very large (~35 fold) reduction in tempering time compared to conventional treatments implies that for beef of a normal fat content, RF heating may have considerable potential in facilitating the rapid preparation of frozen meat for processing. However, further modifications to the application method will be required to optimise the system for tempering high fat meats.

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[1] Power level of 600 W at 10, 11 and 8 min for lean, mixture and fat respectively.