PRODUCING UNIFORMITY OF SURFACE TEMPERATURES AFTER MICROWAVE HEATING OF POULTRY MEAT UNDER CONTROLLED EXPERIMENTAL CONDITIONS

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Introduction

Microwave heating has the potential to rapidly heat the surface of poultry carcasses and portions thus destroying pathogens. However, studies using a standard domestic microwave oven resulted in unacceptable temperature variability on the surface [Goksoy, *et al.*, 1998]. The propose of this study was to use a specially designed microwave cavity together with regular pieces of chicken breast to reduced the variability.

Materials and Methods

All the experiments were carried out using a specialised experimental microwave oven [TC 240, EA technology], designed to provide a reproducible heating performance [Swain *et al.*, 1997]. The microwave oven cavity had temperature controlled inner surfaces, a controlled power supply, a high stable generator, controllable, removable and resetable moving parts (turn table, stirrer etc.). The system had a standard domestic microwave door and a cavity size of 375x372x272 mm and the 2450 MHz microwave generator was continuously variable over a power range 120 to 1200 W.

All the samples consisted of rectangular slabs (80 or 90x40x10 mm) of chicken breast (skin-on). All the samples were kept in a refrigerator at a temperature of 6±1.0°C overnight, placed in a set position in the cavity, skin side up and heated at 935±7W. Conditions used in the different trials are given in Table 1.

In trials 1 and 2 the surface temperature at set positions was measured, immediately before heating and after heating, whilst the sample was still in the cavity, using an IR non-contact thermometer [Model D202A, Digitron Instrumentation, UK]. Temperatures of the skin were determined at the middle, one corner and half way between the corner and the middle. In trials 2 to 7 a mixture of a food simulant consisting of 350g TX151 [Oil Centre Research International Inc., Louisiana, USA] with a 1% salt concentration was prepared and cut into a slab 90x40x10mm and placed in a refrigerator operating at 6±1.0°C overnight. A slab was then placed in a previously prepared aluminium foil container. A pre-weighed sample of chicken breast was then placed on top the simulant and the edges of the container folded over the sample. The sample was then heated in the microwave cavity. In trials 3 to 7 after heating the sample was placed in a polythene bag and immersed in iced water at 0°C for 10 s. The sample was then weighed and the colour measured using a chroma-meter [Chroma Meter II, Minolta Camera Co. Ltd, Japan] and any changes in surface appearance noted.

Results

The average temperature at the corner of the sixteen samples after heating for 20 s in the experimental oven was 60°C with a standard deviation of 7°C. At the centre of the top surface the average temperature was 33°C (SD 6°C) and the mid-way between the corner and middle of the samples 43°C (SD 7°C). All samples showed indications of partial cooking around the edges and corners.

Shielding the bottom, sides and edges with foil and using the TX151 as a microwave absorber reduced the average temperature at the edge to 39°C (SD 3°C) without changing the average temperature on the surface at the middle (33°C, SD 7°C). This produced a mean temperature difference between the edge and middle of 6°C. Maximum temperatures measured at either positions on individual replicates were 45±0.5°C. Slight localised changes in surface appearance were noted on the top surface but no changes were seen on the edges, sides or bottom of the slabs.

As the heating time was increased from 10 to 30 s the average temperature at the corner and middle increased from 30.1 and 28°C after 10 s to 57.7 and 61.6°C after 30 s respectively. The average temperature difference between the corner and the middle of the sample increased in magnitude but changed in sign from 2.1 to -3.9°C. The variability between replicates also increased with heating time. After 10 s temperatures at the corner ranged from 25 to 35°C and at the middle from 25 to 31°C. After 30 s the equivalent ranges were 50 to 63.5°C and 52 to 73°C. Weight loss from the chicken breast samples increased from 0.71% for 10 s of heating to 1.22% after 25 s. However, heating for 30 s did not further increase the percentage weight loss.

Instrumental measurements of colour changes were poorly related to heating time or final temperature. The best relationship was a slight increase in b (yellowness) values of the skin with increase in final temperature (Figure 1). However, there were very large differences in yellowness values between replicate samples before heating.

Discussion

The degree of repeatability measured in the first trial was substantially better than in the previous study [Goksoy *et al.*, 1998]. However, the temperature difference across the surface of the skin was still approaching 30°C after heating. All samples showed

evidence of partial cooking around the edges and corners. In the remaining trials a system was devised that would only allow microwave energy to enter the chicken slab through the top layer of skin. Initially small aluminium trays were constructed to cover the bottom and sides during heating. However, with this system significant signs of cooking were observed around the top edges of the sample and at places on the bottom surface which was in contact with the aluminium. The system was therefore refined with flap over sections to protect the top edges. A slab of a food simulant was introduced below the chicken slab to absorb the microwave radiation and reduce the amount of energy being reflected from the inner base and sides of the container. A piece of corrugated card was also introduced into the base of the container to maintain good contact between the skin of the chicken slab and the containers flaps during heating. Using this system the average temperature difference was substantially reduced from the 30°C without the container to 2.1°C after 10 s heating and 3.9°C after 30 s. The repeatability was also substantially improved. However, even using this improved system surface cooking was observed when the average temperatures had still not achieved values that would eliminate pathogenic bacteria.

Some domestic microwave ovens use weight loss as a measure of cooking. It appears from the small amount of data gathered in this study that there was a relationship between weight loss and heating time. However, the loss appeared to have reached its maximum value before the desired final temperature had been achieved. This could be due to evaporation of the relatively small amount of water present on the surface of chicken skin and the time required for water to diffuse through the skin to replace that lost.

Attempts to use instrumental colour measurements to measure the degree of cooking on the surface of the skin instead of subjective visual examination were unsuccessful.

Conclusions

Heating specially shielded slabs of chicken breast on top of a microwave absorber in a controlled microwave cavity produced more repeatable heating and an average temperature distribution of 58 to 62°C. However, substantial protein denaturation (cooking) of the chicken was still observed and such a process is unlikely to have an industrial application. The result of this work show that microwave heating, even in a very controlled environment, could not produce an even heat distribution on poultry meat without cooking. The feasibility of microwave heating is debatable in terms of reliably decontaminating poultry meat without causing cooking.

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References

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Table and figure

Table 1. Conditions used in main investigation

Trial no.	Sample dimensions (mm)	Weight range (g)	No. replicates	Time (s)	Arrangement
1	80x40x10	38.0-46.0	16	20	none
2	90x40x10	38.1-46.0	7	20	Container + TX151
3	90x40x10	41.5-48.2	5	10	Container + TX151
4	90x40x10	41.5-48.2	5	15	Container + TX151
5	90x40x10	41.5-48.2	5	20	Container + TX151
6	90x40x10	41.5-48.2	5	25	Container + TX151
7	90x40x10	41.5-48.2	5	30	Container + TX151

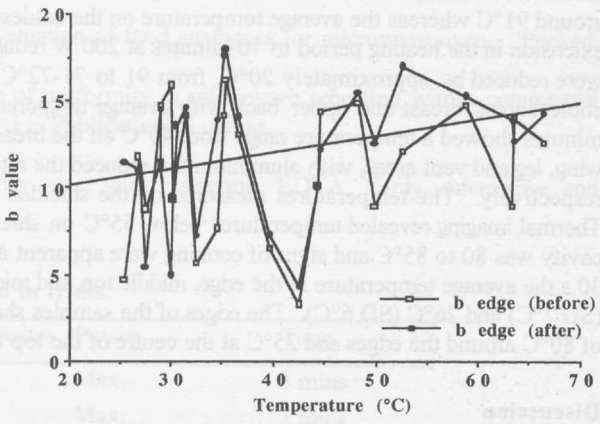

Figure 1. The changes in b* values with increased temperatures on the skin of the chicken samples