Iranian Journal of Veterinary Research, Shiraz University, Vol. 10, No. 4, Ser. No. 29, 2009

Short Paper

The effect of short-time microwave exposures on *Salmonella typhimurium* inoculated onto chicken drumettes

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(Received 8 Mar 2009; revised version 25 Aug 2009; accepted 5 Sept 2009)

Summary

Salmonella species show different disease syndromes and host specificity, according to their antigenic profile. *Salmonella enterica* serovar *typhimurium* is one of the most frequently isolated serovar from food-borne outbreaks. Poultry meat has been identified as one of the principal foodborne sources of *Salmonella*. In this study, the effect of microwave treatment of chicken meat samples which were inoculated with *Salmonella typhimurium* were investigated. Drumette of broiler carcasses were soaked in fully growth of *Salmonella typhimurium* in BHI broth. The swab samples were taken from the inoculated samples, after different times of radiation (5, 10, 15, 20, 25, 30 and 35 sec), using a domestic microwave oven at full power. The bacterial counts were performed on XLD agar. After each experiment the surface temperature of treated samples were measured. It was concluded that the microwave radiation which enhances the surface temperature more than 72°C, can eliminate the superficial contamination of chicken meat with *Salmonella typhimurium*.

Key words: *Salmonella typhimurium*, Microwave, Chicken meat

Introduction

Meat is a rich nutrient matrix that provides a suitable environment for proliferation of meat spoilage microorganisms and common food-borne pathogens, therefore adequate preservation technologies must be applied in order to preserve its safety and quality.

Salmonella species have been considered as one of the most important food borne pathogens, all around the world (Gillespie *et al*., 2003; Malorny *et al*., 2003). Animals are the principal reservoir of this pathogen (Winfield and Groisman, 2003). Foods from animal sources such as beef, poultry meat, egg and milk have been proved to carry these pathogens (Gillespie *et al*., 2003). Raw meat and poultry are recognized as the primary sources for transmitting *Salmonella* species to humans, with 40% of the clinical cases attributed to the consumption of egg and poultry products (Sanchez *et al*., 2002). It has been reported that in addition to mishandling of poultry product and raw poultry carcasses, uncooked poultry meat is also one of the most frequent causes of human infection by *Salmonella* species (Panisello *et al*., 2000).

Salmonella enterica serovar *typhimurium* and *Salmonella enterica* serovar *enteritidis* are the most frequently isolated serovars from food-borne outbreaks throughout the world (Herikstad *et al*., 2002). *Salmonella* species show different disease syndromes and host specificity, according to their antigenic profile (Lim *et al*., 2003).

High frequency energy includes microwave (MW) and radiofrequency energy belongs to the non-ionising radiations, microwaves lie between the infrared and radio frequency portions of the electromagnetic spectrum (Jay *et al*., 2005). In a microwave oven the heating of food results from molecular friction between water molecules under an oscillating electric field of specific frequency (Pucciarelli and Benassi, 2005).

Heating by MW energy is used for several purposes, e.g., cooking, pasteurization, sterilization and blanching of foods (Giese, 1992; Datta and Davidson, 2001). The safety of microwave cooking in relation to foodborne pathogens is questioned. There are studies reporting incomplete inactivation of microorganisms including pathogens in inoculated cooked foods or reheated in MW ovens (Heddleson and Doores, 1994; Datta and Davidson, 2001).

The aim of the present study was to investigate the effect of different times of microwave heating on the fate of *S. typhimurium*, inoculated onto drumette of broiler carcasses.

Materials and Methods

Equipment and samples

Microwave irradiation was performed in a household microwave oven (Delonghi, type MW-675FI, with a rotating glass plate, a frequency of 2,450 MHz, and power of 850 W). The microwave was used at full power for heating the chicken portions. The experiment was carried out in five replicate. In each replicate of the experiment, eight fresh drumettes (the small fleshy part of a chicken wing, often fried and served as an appetizer) of broiler carcasses, which sold in wrapped packages, were obtained from a supermarket. All samples were transferred to the laboratory within 1-2 h at 4°C in insulated boxes and stored at 4°C until use within 24 h after purchase. The drumette of broiler carcasses was treated with H_2O_2 + Ag^+ (sanocil) according to the manufacturer's instructions at room temperature as a sanitizer, and then washed three times with sterile distilled water to remove the residuals. All samples were examined for any pre-existing contamination with *S. typhimurium*, following the method described by Vanderzant and Splittstoesser (1992).

Preparation of the *S. typhimurium* inocula

S. typhimurium (ATCC-25923) was used for inoculation in each experiment. Stock cultures of the strain were prepared in TSI Agar (Merck) slants, stored at 4°C and sub cultured every 4 weeks. Pure cultures of *S. typhimurium* were prepared by sub culturing the test strain into 500 ml of brain heart infusion broth (BHI broth) (Merck), following incubation at 37°C for 24 h. The concentration of the resulting culture of *S. typhimurium* was determined by preparing serial dilutions and surface plating on XLD agar (Merck). This culture media were used for inoculation of the chicken meat samples.

To inoculate the same dose of bacteria in repeating the experiment, the absorbance of the cultured media was also determined in 600 nm wave length, using a spectrophotometer apparatus (Jenway 6105, Essex, England).

Inoculation procedure and microbiological analysis

The eight portions of chicken drumettes were immersed in 500 ml of the cultured *S. typhimurium* in BHI broth for 10 min. They were drained by dripping on absorbent sterile cheesecloth for another 10 min in laboratory environment and then they were placed in sterile glass Petri dishes. One sample was reserved for estimating the *S. typhimurium* concentration of the tested portions. The remaining seven samples were heated individually into the microwave oven operating at full power for 5, 10, 15, 20, 25, 30 and 35 sec, respectively. Surface temperatures in the approximate center of the upper surface of the samples were measured immediately after each exposure, using a thermometer which was placed beneath the skin of the irradiated sample.

Following microwave heating, after about five min the upper surfaces of the samples were swabbed, using a template (wet and dry swabbing method) (Vanderzant

and Splittstoesser, 1992).

To determine the numbers of surviving *S. typhimurium* cells after each exposure, decimal dilutions from each swabs containing tube were prepared and total viable count were performed by surface plating on XLD agar (Merck) following incubation at 37°C for 24 h.

Statistical analysis

The statistical analysis was performed using SPSS statistical software (version 11). Non-parametric one-way ANOVA (Kruskal-Wallis test) were used to determine the effect of time of microwave exposure on *S. typhimurium* viability. The relationship of inoculated bacterial population viability with temperature of samples due to microwave exposure was examined with Pearson's correlation.

Results

Preexisting contamination with *S. typhimurium* was not detected in chiken meat samples. The concentration of cultured media inoculated with *S. typhimurium* was 8×10^7 cfu/ml, using total viable count method (Vanderzant and Splittstoesser, 1992), and its absorbance at 600 nm was equal to 0.619.

Destruction of *S. typhimurium* as a function of microwave exposure time of small chicken portions are shown in Fig. 1 and destruction of *S. typhimurium* in small chicken portions by microwave exposure as a function of the end point surface temperatures of the chicken portions are shown in Fig. 2. Elimination of *S. typhimurium* was observed after the end of 35 sec exposure time, when the surface temperature increased to 72°C (mean).

Statistical analysis showed that samples with 5, 10 or 15 seconds of microwave exposure did not have significant difference in regard to population of inoculated bacteria, but they had significant difference with samples that exposed longer duration of time to microwave exposure (20, 25, 30 and 35 sec). Pearson's correlation showed a significant correlation between the bacterial population and temperature of samples due to microwave exposure ($P<0.001$, $r = -0.94$ and $r^2 = 88\%$).

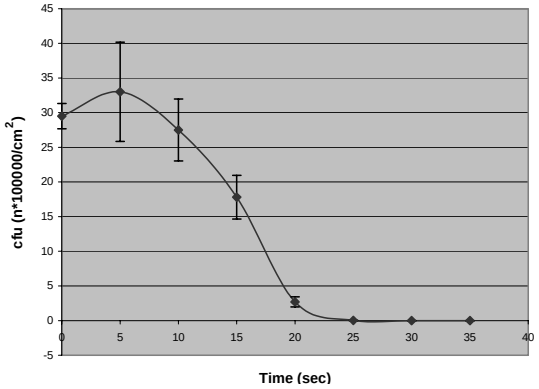

Fig. 1: Destruction of *Salmonella typhimurium* as a function of microwave exposure time in drumettes of broiler carcasses

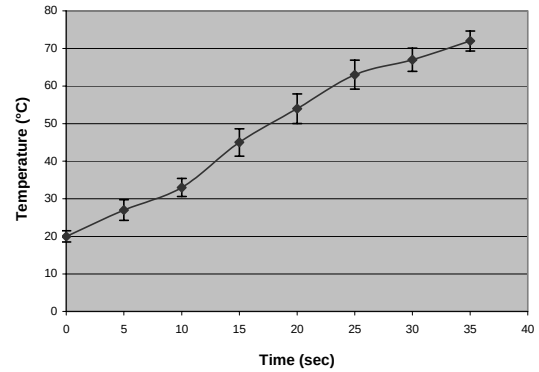

Fig. 2: Final surface temperature of drumettes after different time of microwave exposure

Discussion

Microwave ovens have become common household appliances in developed countries and, to some extent, in developing countries. This relatively inexpensive technology is commonly used to cook or warm foods in homes, offices, and some restaurants. With respect to consumer safety, the research reported here shows that microwave radiation can be used to control (to reduce or sometimes to completely eliminate) microbial potential pathogens in food.

evidence suggests that microwaves are being used more frequently than ever before to cook raw foods. Although microwave reheating has been shown to be a generally reliable method of reducing microbiological pathogens, little research has been performed on its efficacy to promote microbiological safety in cooking raw foods (Farber *et al*., 1998).

According to our study, induction of 72°C of superficial temperature in chicken

meat portions could eleminate the inoculated bacteria, which its primary contamination rate with *S. typhimurium* was 2.95×10^6 cfu/cm^2. Duration of radiation with full power to produce this temperature was 35 seconds.

A 5-log reduction of the viable count was also reported for *E. coli* suspension exposed to full power of microwave radiation (600 W) in 80 sec (Woo *et al*., 2000). In another study microwave radiation which produced an internal temperature of 85°C in fresh whole roasting chickens, could eleminate *S. typhimurium* (Schnepf and Barbeau, 2007). Although the inoculated bacteria in our study were eliminated after 35 sec of microwave exposure, but it should be noted that other parameters such as size and shape of the radiated meat samples may influence the elemination of inoculated bacteria. In a study on chicken breast portions, elimination of *E. coli* O157:H7 cells occurred after 35 sec of microwave exposure at 73.7°C, but when whole chickens were exposed to microwave radiation, even with 92°C in some area, viable cells of *E. coli* O157:H7 were recovered from all samples of whole chicken (Apostolou *et al*., 2005). In another study survival of pathogens such as *Salmonella* spp. (Schnepf and Barbeau, 2007) and *Listeria monocytogenes* (Farber *et al*., 1998), in food heated in microwave ovens, is attributed to the non-uniform heating and their asymmetrical form.

Extreme variability of surface and subsurface temperatures has been reported by other researchers in meat samples heated by microwaves, but the central area is where the least temperature increase is expected to occur (Farber *et al*., 1998; Göksoy *et al*., 1999). In our study only surface temperature measurements were taken from the sample's centre. Measuring the temperature of sample's centre also prevents the "edge-heating effect" which is overheating of corners and edges of foods in a microwave field, caused primarily by the uneven energy distribution during microwave heating (Huang and Sites, 2007).

In our study the swabbing of samples were performed after five min of microwave exposure, because it was reported that post-heating holding times of two or more min, increases bacterial destruction (Heddleson *et al*., 1994). Survival of some inoculated pathogens in meat portions after microwave exposure may be due to immediate sampling.

The primary concern associated with microwave cooking is uneven heat distribution, which results in the formation of hot and cold spots in the food (Farber *et al*., 1998). To guarantee microbiological safety it has been recommended to cover the food with wax paper and checking the temperature in at least three different sites (Farber *et al*., 1998).

In conclusion, consumers can use microwave ovens to significantly reduce microbial pathogens in foods like chicken meat portions. Microwave irradiation may be considered as a cost-effective, practical, fast, easy, and safe method of decontaminating foods.

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