Food Refrigeration & Process Engineering Research Centre

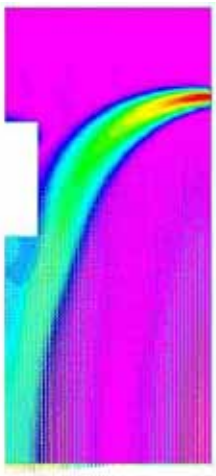
THE GRIMSBY INSTITUTE of Further & Higher Education

Development and Use of an Atmospheric Steam Decontamination System for Poultry Decontamination

Background

Large scale steam “pasteurisation” systems are being employed commercially in the USA for treating red meat carcasses. However, there is still much that is unknown regarding the effectiveness and optimisation of steam treatments and there is also interest in using such technologies for treating much smaller meat carcasses, such as poultry. This paper describes the development and evaluation of a pilot atmospheric steam cabinet for treating meat carcasses.

Materials and Methods



The basic principle behind the use of atmospheric steam for decontamination is to utilise a vessel with an open base, filled with steam. The steam remains in the vessel because it is less dense than the surrounding air. To treat the product, it is raised into the steam environment for the required duration.

Initial studies were carried out using a very simple prototype rig consisting of a large, food grade, plastic barrel with the base removed mounted on three metal legs. In the prototype, steam was supplied from a boiler with the steam line entering near the top of the barrel and was fed into an upward pointing sparge pipe to distribute the steam. The steam flow was controlled by opening the solenoid valve from the boiler and manually adjusting an isolation valve to achieve the desired flow rate. An initial temperature test was conducted using a mock food product with thermocouples attached to the surface. The measured temperature in the vessel was less than that expected for steam at atmospheric pressure (c.100°C). Investigations revealed this to be due to air entrapped by the turbulence of the steam coming out of the sparge pipe at a high velocity.

Thus the method of steam introduction was altered to create a more stable flow. The steam inlet was moved to the top of the vessel where it exhausted into a plenum chamber. From the plenum chamber, steam entered the body of the vessel through a perforated baffle plate. This improvement produced a much more stable flow within the vessel, with excess steam gently spilling out from the base of the vessel. No air was entrapped and a much higher temperature was produced within the vessel. Tests were then carried out to determine the uniformity of steam distribution and the effect on the distribution of inserting samples.

CFD modelling was carried out to see the effect of air entrainment caused by the product moving from the air into the steam (left).

Using the experience gained from the initial pilot plants and the CFD studies, a more user and food friendly atmospheric pilot plant has been designed and constructed in order to conduct investigation in commercial plants.

The final experimental atmospheric steam treatment equipment (right) consists of a double-skinned stainless steel treatment chamber supported by two legs. The front of the vessel houses a double glazed unit to allow the product to be viewed during treatment. The treatment sample is raised into the chamber by a pneumatic cylinder controlled by an adjustable electronic timer. Steam is provided by three 2.8kW boilers operating in parallel. Steam enters a plenum chamber at the top of the vessel and is evenly distributed into the main chamber through a baffle. A lip around the bottom of the chamber collects condensate and drains it to the back of the unit, preventing hot water falling onto experimenters as the system is loaded.

Results & Discussion

The effects of various atmospheric steam treatments on the appearance, shelf-life and microbiological quality of chicken have been investigated. Initial experiments (James et al., 2000a) showed that a 10s steam treatment on naturally-contaminated chicken breast portions resulted in a 1.65 log10 CFU (colony-forming units)/cm2 reduction in aerobic plate count (APC). However, in comparison with untreated controls, this treatment did not extend the shelf-life. Overall, results indicated that significant reductions in microbial counts could be achieved for chicken meat using steam. Further work has looked at the effectiveness of steam against Campylobacter spp., under laboratory and commercial conditions (James et al., 2005). In experimental studies whole chicken carcasses, inoculated with ca. 6 log10 CFU/cm2 Campylobacter jejuni and Escherichia coli K12, were treated with steam at atmospheric pressure for up to 20s. Numbers of C. jejuni were reduced by ca. 1.8 log10 CFU/cm2 in 10s and 3.3 log10 CFU/cm2 in 20s. Corresponding reductions in numbers of E. coli K12 were 1.7 and 2.8 log10 CFU/cm2. However, the 20s treatments caused the skin to shrink and change colour. The optimum steam treatment for maximum effect on C. jejuni and E. coli, least skin shrinkage and change of colour was concluded to be 10-12s. Additional trials in a commercial poultry plant using naturally contaminated carcasses were hampered by low initial levels of Campylobacter spp. (~1 log10 CFU/cm2) but variable reductions of about 2 log cycles were obtained for pseudomonads and Enterobacteriaceae. Numbers of campylobacters were reduced, but not eliminated. It was considered that changes to appearance of skin-on carcasses or portions would be acceptable to many consumers. Unacceptable carcasses produced (or more severe treatments with greater kill potentials) could be used for production of 'skin-off' portions. Additional work has been carried out on pork, lamb (James et al., 2000b), and beef (and also fish, fruits and vegetables).

The surface temperature is a critical parameter in the destruction of pathogenic and meat spoilage microorganisms in steam systems. However, measuring the temperature of the surface of the meat is a difficult procedure. There is a marked temperature profile from the surface into the environment and from the surface into the meat. Thermal modelling can be used to predict the surface temperature but reliable data on the surface heat transfer coefficient is required. An experimental protocol based on that of Creed & James (1985) has been used to determine the surface heat transfer coefficients in the atmospheric steam cabinet to enable further optimisation of the system. The overall effective surface heat transfer coefficient determined for the steam cabinet were 1215.8 W/m2/K at 100°C, much higher than those used in previous studies on modelling steam decontamination systems (Hoke et al., 2003). This should allow much better prediction of meat surface temperatures and subsequently aid the design and optimisation of similar steam intervention systems.

Conclusions

A pilot scale atmospheric steam cabinet has been developed and successfully used in many experimental trials involving poultry, pork, lamb, and beef (and also fish, fruits and vegetables) both in a laboratory setting and alongside commercial processing lines in industry to demonstrate the effectiveness of steam interventions in lowering microbial loads.

Acknowledgements

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Contacts

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