Comparison of physical systems (atmospheric steam, and different types of water sprays) for decontamination of chicken carcasses.

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Abstract – The aim of this study was to compare the anti-microbial effect of misting (low flow, low pressure), deluge (high flow, low pressure) and high intensity (high flow, high pressure) cold water spray systems, and atmospheric pressure steam treatments on naturally occurring *Campylobacter*, Enterobacteriaceae and *Pseudomonas* spp on the breastskin and neckskin of chicken carcasses.

Chicken carcasses were collected before chilling from a local processor and treated in purpose-built automated spray and steam rigs simulating the application of physical interventions on a commercial line. Untreated control carcasses were also examined to provide baseline data of the initial microflora levels. Microbial numbers per g were determined using colony count techniques on selective agar media.

For statistical analysis, the results were subdivided into six microbe-type/skin-part combinations.

No single treatment gave the best antimicrobial effect across all combinations.

Comparison of the 15s treatments over all microbe-type/skin-part combinations showed steam treatment to be the most effective, producing significant ($P<0.01$) reductions on the breastskin of 1.28, 1.02, and 1.32 $\log_{10}$ CFU/g for *Campylobacter,* Enterobacteriaceae and *Pseudomonas* spp. respectively. The deluge system was the most effective of the 15s water spray treatments, giving the highest mean reduction of 0.68 $\log_{10}$ CFU/g for *Campylobacter* on breastskin.

Increasing spray treatment time did not improve reductions, however increasing atmospheric steam treatment time improved reductions, but was limited by degree of acceptable surface change.

Keywords— **Poultry, Washing, Steam.**

I. INTRODUCTION

Raw poultry meat has been implicated as a major source of human infection, by cross-contamination in the kitchen of other foods eaten without further cooking, undercooking and probably direct hand-to-mouth transfer during food preparation [1]. In a UK Food Standards Agency (FSA) survey in 2009 of chicken meat at retail, *Campylobacter* was present in 65% of the samples tested [2]. A European Union (EU) wide baseline survey in 2008 found that at a Community level the prevalence of *Campylobacter*-contaminated broiler carcasses was 75.8%, although it should be noted that the level of prevalence did vary widely, from 4.9 to 100%, between Member States [3].

Whilst many studies have considered the use of chemical decontaminants for reduction of surface contamination, there is debate over the safety and long-term residue effects for many of these. Decontaminant systems based on simple physical concepts such as spray washing with cold potable water or condensing steam onto the carcass surface have wider public (and food safety authority) acceptance.

Spray washing of poultry carcasses with cold water after evisceration to remove faeces, blood, dirt, and other organic material from the surface of carcasses prior to chilling is standard practice in many countries, but surprisingly few studies have evaluated the performance and effectiveness of poultry washers within the processing plant [4]. Many washing systems are modified by their users and "*washing systems installed in one plant may not perform equally well in another plant*" [4]. Physically removing bacteria using sprays of cold water alone has been shown to be only partially effective, since attached/entrapped bacteria have been shown to be particularly difficult to remove with most studies reporting reductions of <1 log cycle.

Steam at 100°C has a substantially higher heat capacity than the same amount of water at that temperature. This latent heat of evaporation is released when steam is allowed to condense onto a surface and the surface temperature is rapidly increased. Additionally, steam molecules are smaller than most microbes, thus permitting heating effects to be delivered into cavities in which microbes could be sheltered if using other means of treatment.

A modified version of the Frigoscandia Steam Pasteurisation System (SPS) developed for beef has been evaluated on poultry carcasses [5]. Conditions similar to those used for beef (90°C for 12 s) did not produce statistically significant reductions in Aerobic Plate Counts (APCs), Enterobacteriaceae or thermophilic campylobacters. Increasing the treatment time to 24 s gave reductions of 0.75, 0.69 and 1.3 $\log_{10}$ CFU/g respectively. However, this resulted in visible damage to the skin.

The study reported in this paper compares non-controversial physical poultry decontamination methods based on condensing atmospheric steam and potable cold water spraying under controlled conditions for use in commercial plants. The work was carried out under near to actual, commercial conditions to minimise the problems of extrapolating from laboratory studies. This will go some way to evaluating the effects and addressing practical issues for a meat industry implementation.

II. MATERIALS AND METHODS

Carcass collection procedures were designed to provide experimental carcasses as close as possible to those at the point on a commercial line where the steam or spray treatment would be implemented.

Carcasses were treated in a purpose-built automated spray rig simulating implementation of cold water spray treatment as would be used in a commercial poultry processing facility. A variety of spray system configurations (Table 1) were set within the rig through which carcasses were driven on an overhead shackle line (Figure 1). The drive speed was varied to give different treatment times.

The steam system comprised an open based treatment chamber fed with steam at atmospheric pressure. Carcasses were lifted singly into the chamber on a shackle attached to a time delay pneumatic cylinder to produce different treatment durations. A series of pre-trials concluded that the maximum treatment duration without irreversible surface change was 15 s.

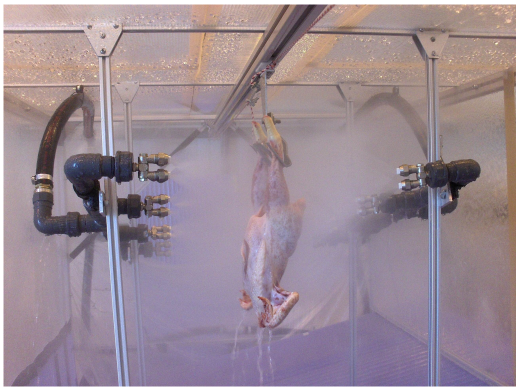

Figure 1. Carcass in spray equipment.

After treatment, neckskins and the whole of the breastskin were removed from each carcass and examined for numbers of viable *Campylobacter*, Enterobacteriaceae and presumptive *Pseudomonas* spp. All bacterial counts were transformed to $\log_{10}$ CFU/g values for subsequent data analysis. The treatment mean and variance were calculated from replicate results on all experimental days of that treatment. The mean and variance for the controls for each treatment were derived from the untreated controls for each of the days on which that particular treatment was performed.

Results were collated and analysed in MS Excel, using Student T-test (2 tailed) at 99% confidence for all tests of significance.

III. RESULTS

The mean and variance of microbial levels before and after treatment are shown in Figure 2**Fout!Verwijzingsbron niet gevonden.** for all microbe-type/carcass-part combinations. Overall, it can be seen that these physical decontamination methods gave no substantial effect. Only 13 of the 72 conditions evaluated gave a significant ($P<0.01$) reduction.

Table 1. Spray system characteristics

Spray type	Function	Characteristics
'Misting' (M)	'Soft' spray to gently deposit onto surface (as would be used for chemical deposition)	Flat fan nozzles, fine droplets, low flow, low pressure
'Rinsing' (R)	Reduce surface heat after steam treatment with cold water spray	Full cone nozzles: large droplets, high flow, medium pressure.
'Deluge' (D)	Large volumes to 'float' organisms/debris from surface	Full cone nozzles: large droplets, high flow, low pressure.
'High Intensity' (H)	High impact for mechanical dislodgment of detritus and organisms followed by deluge rinse for removal.	Flat fan, small droplets, medium flow, high pressure then; Full cone nozzles: large droplets, high flow, medium pressure.

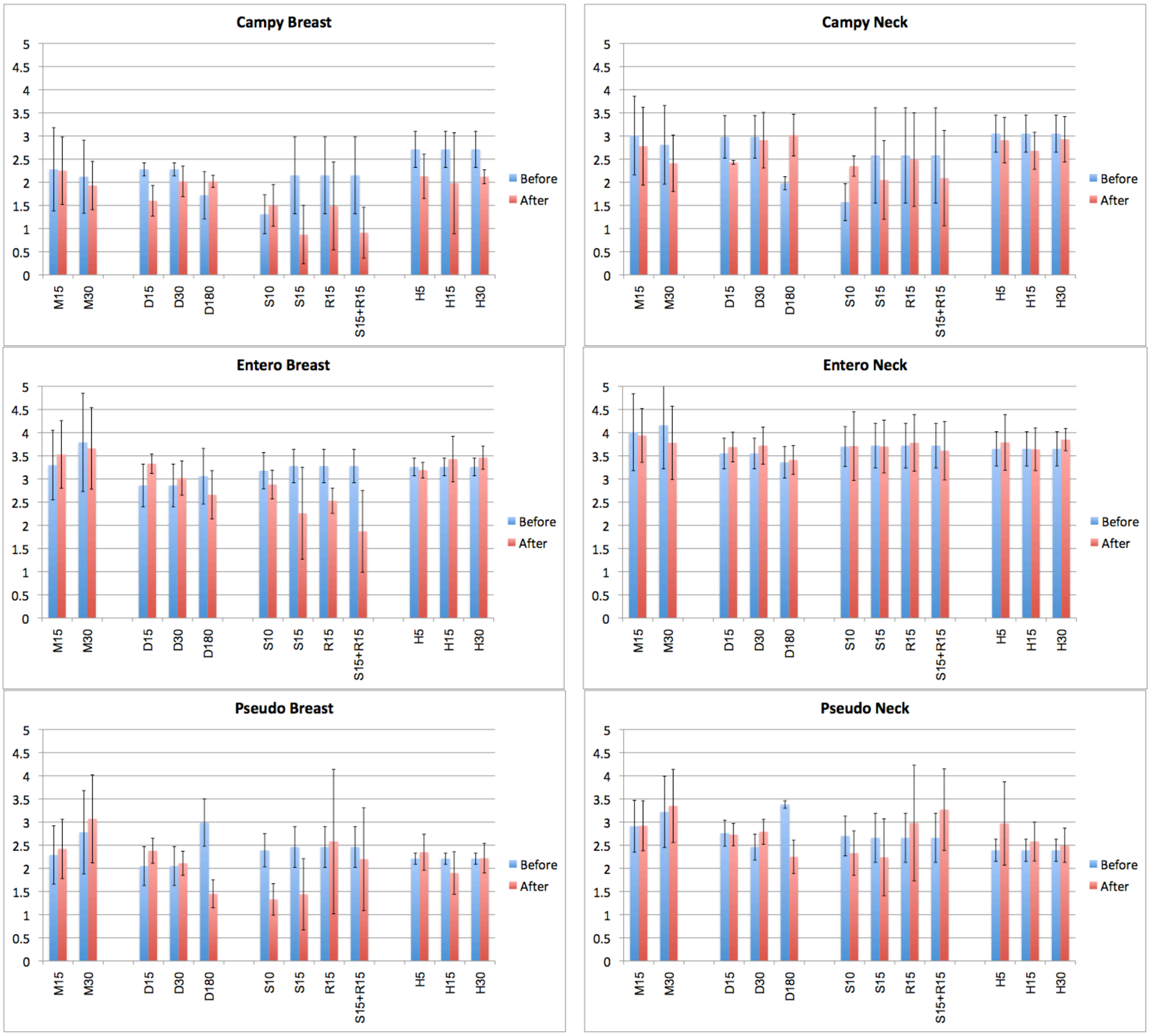

Figure 2. Mean $\log_{10}$ CFU/g (±1SD) for water and steam treatments. KEY: M15 = CW mist 15s; M30 = CW mist 30s; D15 = CW deluge 15s; D30 = CW deluge 30s; D180 = CW deluge 180s; S10 = Stm 10s; S15 = Stm 15s; R15 = CW rinse 15s; S15+R15 = Stm 15s +CW Rinse 15s; H5 = CW high-intensity 5s; H15 = CW high-intensity 15s; H30 = CW high-intensity 30s. CW = Cold Water; Stm = Steam

IV. DISCUSSION

Many treatments gave greater reductions on the breastskin than on the neckskin. This is likely due to the smoother breastskin providing fewer crevices and folds to harbour organisms and detritus than the neckskin.

Comparison of the 15 s treatments over all organism-type/skin-part combinations shows the 15 s steam treatment to be the most effective, producing significant (P<0.01) reductions on the breastskin of 1.28, 1.02, and 1.32 $\log_{10}$ CFU/g for *Campylobacter,* Enterobacteriaceae and *Pseudomonas* spp. respectively. Previous studies [6] report a 1.65 $\log_{10}$ CFU/cm^2 reduction in TVC on naturally-contaminated chicken breast portions from a 10 s atmospheric steam treatment; these are broadly equivalent values.

The best performing cold water 15 s spray was the deluge treatment producing a significant (P<0.01) reduction of 0.68 $\log_{10}$ CFU/g for *Campylobacter* on the breastskin. This finding is supported by Escudero-Gilete *et al*. [7] who report that for equal treatment durations, flow rate is the most important spray parameter for washing efficacy; in these trials the deluge system had the highest flow rate.

For most spray systems there was no benefit in increasing treatment duration. The only exception seen was for *Pseudomonas* spp when the deluge system duration was increased from 30 s to 180 s, however *Campylobacter* and Enterobacteriaceae reductions showed no significant corresponding change. Increasing steam treatment from 10 to 15 s improved reductions for all organism-type/skin-part combinations. However, 15 s is at the limit of acceptable surface change and treatment duration cannot be increased to further improve the reductions.

V. CONCLUSIONS

A 15 s atmospheric steam treatment produced greater reductions than any of the 15 s cold water spray configurations evaluated.

Increasing spray treatment duration has little effect on reductions achieved.

Increasing atmospheric steam treatment duration improves reduction, but the maximum duration is limited by degree of acceptable surface change.

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