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Effect of extending processing plant operating time on the microbiological quality and safety of broiler carcasses

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ABSTRACT

In Australia, increased consumer demand for chicken meat and socioeconomic pressures have forced poultry operations to extend plant operating time with delayed spin-chiller emptying and cleaning to maximise water use efficiency. There are concerns that these measures may compromise the microbiological quality and safety of the product. Therefore, the objective of this trial was to determine the microbiological status of broiler carcasses collected hourly during 24 h and 48 h continuous chiller operation within a three week period (total $n = 196$). Carcass rinses were analysed for total viable count, *Escherichia coli* and *Campylobacter* spp. counts, and *Salmonella* prevalence. Corresponding spin-chiller parameters (pH, oxidation-reduction potential [ORP], core temperature and HOCl concentration) were recorded. There was no statistically significant difference ($P > 0.05$) in bacterial populations and spin-chiller parameters when various sized chickens were processed. Therefore, the microbiological data and consequent quality were shown to be statistically equivalent between carcasses sampled from 24 h to 48 h continuous processing using a fully automated (water temperature, pH and chlorine control) spin-chiller. However, improvements to processing, including rehang and scald hygiene, and weight-specific hypochlorous acid concentrations, should be researched in order to further reduce bacterial contamination.

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1. Introduction

Poultry, in particular chicken, has recently become the most consumed animal protein source in Australia, with 43 kg consumed per person per annum (ACMF, 2011). The demand for poultry meat is projected to increase over the next few years, which has driven greater production (ACMF, 2011). Socioeconomic pressures to reduce water and energy usage have forced the poultry industry to maximise water use efficiency in commercial unit operations, such as immersion scalding, antimicrobial rinses and chilling. However, little is known about the effect that these measures have on the microbiological status of processed broiler chicken carcasses, which have been identified as a common source of *Salmonella* and *Campylobacter* infections in humans (FAO/WHO, 2009).

The major Critical Control Point (CCP) in poultry processing is carcass cooling, which delays microbial, physical, biochemical and histological degradation (Souza et al., 2012). Currently, in Australia, there are three types of poultry carcass cooling systems used commercially: (i) dry air, (ii) immersion, and (iii) combined air-immersion chilling (FSANZ, 2010). Air cooling, commonly used in Europe, is accomplished by conveying (via shackles) carcasses through a large refrigeration chamber which decreases the carcass core breast temperature to < 5 °C (Mielnik, Dainty, Lundby, & Mielnik, 1999). Immersion (spin-) chilling involves carcasses passing into a cold (<4 °C) water-filled chamber, often containing antimicrobial solutions such as sodium hypochlorite or peroxyacetic acid (Cox & Pavic, 2010; James, Vincent, de Andrade Lima, & James, 2006; Oyarzabal, 2005). While water usage could be reduced through introduction of air chilling, microbial counts tend to be lower on carcasses immersed in chlorinated cold water (Allen, Corry, Burton, Whyte, & Mead, 2000; Berrang, Meinersmann, Smith, & Zhuang, 2008; James et al., 2006).

In spin-chillers, carcasses are propelled, either by a paddle or screw system, in a direction counter-current to the flow of water. Low

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temperature, chemicals and washing collectively result in microbial reduction and death (FSANZ, 2010; Souza et al., 2012; Voidarou et al., 2007). Additionally, the advent of automated and highly controlled spin-chiller technology has lead to improvements in carcass quality (Fellows, 2000). In modern spin-chillers, such as those manufactured by Cooling and Applied Technologies (CAT), pH and chemical concentration (measured indirectly in mV using oxidation-reduction potential [ORP]) are constantly monitored and adjusted to bactericidal concentrations (FAO/WHO, 2009). These set parameters, coupled with microbial reduction targets, comparing pre- and post-immersion bacterial levels, ensure that the spin-chillers are operating effectively (FAO/WHO, 2009; Souza et al., 2012).

Spin-chiller water can become contaminated with bacteria present on the carcass surface and in the cavity, leading to cross-contamination and potentially compromising product safety (FAO/WHO, 2009; Smith, Cason, & Berrang, 2005). Therefore, European, Brazilian, USA and Australian regulations state that spin-chillers must be emptied, cleaned and sanitised after every work shift (8 h), or a minimum of once per day (Anonymous, 1992; Smith et al., 2005; Souza et al., 2012; Standards Australia, 2006). Such rigorous measures have created substantial debate about the socioeconomic and environmental effects from the resulting increase in wastewater (Souza et al., 2012). This concern for water and cost minimisation prompted a recent study in Brazil comparing carcass quality after continuous immersion, with overflow and 2 ppm free chlorine, for 8 and 16 h of operation (Souza et al., 2012). These researchers found aerobic mesophilic counts were not significantly different and concluded that spin-chiller cleaning could be postponed until after 16 h of processing (Souza et al., 2012). Based upon these findings and the need for local data, the objective of the current study was to compare the bacterial load on broiler carcasses after 24 h and 48 h continuous spin-chiller operation.

2. Materials and methods

2.1. Processing plant

Broiler carcasses were processed at a commercial poultry slaughterhouse located in New South Wales, Australia. The plant operates 18–24 h per day and has a daily slaughter capacity of 200,000 birds. Cleaning and sanitation of the processing line occurs within a 6–8 h window post-shift. The processing plant was fitted with the following equipment: immersion scald tank (Linko, Air jet A12 110, Denmark) operated at 55 °C, 2 min contact time, and overflow of 600 mL/per bird; evisceration line (Stork Nu Tech Nuova Series, The Netherlands); inside-outside washer (20 ppm chlorinated water, 550 mL per bird [Stork Nu Tech Nuova C1137, The Netherlands]) and a CAT spin-chiller (Cooling and Applied Technologies, AR, USA with HOPE Accufeed Monitoring, GA, USA). This spin-chiller has a 19,000 L pre-wash chamber, which operates nominally at 12 °C, pH 6.0 to 6.5, ORP 750–850 mV, 6 ppm hypochlorous acid (HOCl) and a 850 mL overflow per bird and a 150,000 L main chiller chamber which is operated as previously mentioned with a longer residue time of 120 min and a water temperature of 1 °C. The processing line speeds are adjusted according to live bird weigh; small (<2.2 kg) are processed at 150 birds/min.; medium (2.2–2.8 kg) are processed at 130 birds/min and large (>2.8 kgs) are processed at 110 birds/min.

2.2. Carcass sampling

The processed broilers represented 171 b from 39 farms 14 free range and 25 conventional farms. The samples were taken hourly during a 48 h plant operating time within a three week period between May and June 2012. Core temperature of each carcass was measured using a digital temperature probe before placing the sample into a sterile rinse bag. The corresponding pH and oxidation-reduction potential (ORP) from the HOPE display was recorded. A 100 mL sample of overflow water was tested for HOCl concentration (Lovibond CheckitDirect, Amesbury, UK) and recorded. Each carcass was uniquely identified and stored at 4 °C until daily refrigerated transport to the testing facility.

These carcasses were then grouped into sampling rounds, each round from a 48 h period, with sub-sample sets at 24 and 48 h matched with their corresponding measured variables (core temperature, time samples, weight, pH, ORP and HOCl concentration). Rounds (R) 1 (40 b from 22 farms) and 2 (40 b from 23 farms) were performed in the first week (Monday/Tuesday and Thursday/Friday, respectively) of the trial period to measure the efficacy of mid-week cleaning. To be able to demonstrate repeatability of processing line and chiller setup, R3 (40 b from 22 farms) and R4 (51 b from 25 farms) were performed on Monday/Tuesday shifts over two separate weeks. The horizontal data, accumulated over three weeks, was used to measure the routine effectiveness of 48 h continuous processing and to sample a more diverse range of birds from different broiler farms.

2.3. Microbiological analysis

All samples were tested at an accredited (ISO 17025) laboratory. The core temperature of the carcasses was measured upon receipt. Each carcass was placed aseptically into a rinse bag for sample preparation in accordance with AS 5013.20-2004. Briefly, the carcass was weighed on a tared top pan balance and rinsed in 500 mL of buffered peptone water (Oxoid, Basingstoke, Hampshire, UK) for 2 min by vigorous hand massaging. A 100 mL aliquot of rinsate was transferred into sterile sample jars for further analysis.

Total viable count (TVC) and *Escherichia coli* were enumerated using the TEMPO® system (bioMérieux SA, Marcy-l'Etoile, France). Briefly, a 1 mL volume of sample or appropriate dilution was inoculated into TEMPO® TVC (1:400 dilution) or TEMPO® EC (1:4 dilution) vials reconstituted with 3 mL of sterile reverse osmosis water. Each sample vial was associated with a uniquely barcoded card, which was filled, incubated and read according to the manufacturer's protocol.

Campylobacter was enumerated using the ISO/TS 10272-2:2006 spread-plating method, with two internally validated modifications: (i) CampyFood agar (CFA; bioMérieux SA) and Skirrow (CSK; bioMérieux Australia Pty Ltd, Murarrie, Queensland, Australia) were used as the selective agars, (ii) suspect colonies were confirmed using the Vitek® MS RUO system (bioMérieux SA) (Martiny et al., 2012).

Qualitative analysis of *Salmonella* was performed using the VIDAS® UP *Salmonella* (SPT; bioMérieux SA) assay according to the manufacturer's instructions, with an internally validated modification to include a 2–4 h pre-enrichment prior to supplement addition to aid resuscitation of sub-lethally injured cells. Suspect positive samples were then confirmed by selective enrichment in Rappaport-Vassiliadis Soy broth (RVS; bioMérieux SA), isolation on selective differential split plates incorporating xylose lysine deoxycholate and Hektoen agars (XLD/HEK; Thermofisher Oxoid, Adelaide, Australia), confirmation on chromID® Salmonella agar (bioMérieux Australia Pty Ltd) and serogrouped using commercial antisera (PROLAB Diagnostic, ON, Canada). All presumptive *Salmonella* isolates were sent to a Australian *Salmonella* Reference Centre laboratory (IMVS, Adelaide, Aust) for sero and phage typing.

2.4. Data analysis

Carcass samples were collected hourly ($n = 24$) which equated to a sampling ratio of 1:8333. Additional to time-based analysis, the

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