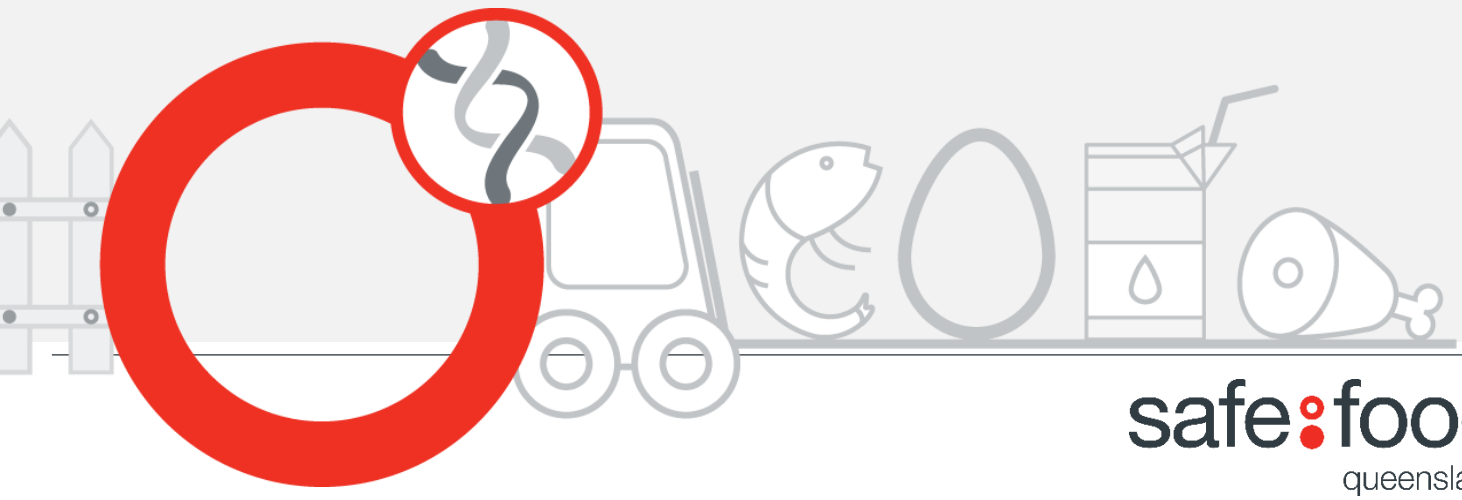
Microbiological verification survey of primary processing facilities for poultry meat in Queensland – 2019

Safe Food Production Queensland



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About this document

This document reports the results of a microbiological verification survey of Queensland poultry meat primary processing facilities performed in 2019. The purpose of this survey was to examine the ability of these facilities to manage microbiological hazards associated with poultry meat (e.g. *Campylobacter*) and promote awareness of the food safety risks associated with these activities. This work builds on the achievements of previous system verification surveys completed by Safe Food Production Queensland in 2008, 2012 and 2015 and complements a multi-state study of *Campylobacter* prevalence in retail chicken products completed by Walker *et al.* (2019).

Information generated from this work will assist the continued evaluation of the performance of the meat food safety scheme (*meat scheme*) under the Food Production (Safety) Regulation 2014 and support the Safe Food Production Queensland Statement of Strategy 2020-2023. This work also contributes to the monitoring and surveillance component of Australia's Foodborne Illness Reduction Strategy 2018–2021+. This national strategy aims to reduce the number of food-related human cases of campylobacteriosis and salmonellosis in Australia and furthers the initiative undertaken by the Queensland 2015-2018 Senior Officers Working Group Pathogen Risk Reduction Strategy.

Any enquiries about this document should be directed to Safe Food Production Queensland on (07) 3253 9800 or email info@safefood.qld.gov.au.

Acknowledgements

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Executive summary

Campylobacter and *Salmonella* species are the most prominent microbiological food safety hazards associated with poultry meat. Under the requirements of both the Australian Standard for Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption (AS4465:2005) and Standard 4.4.2 of the Australia New Zealand Food Standards Code, microbiological hazards associated with poultry meat must be controlled through the processing chain to produce a product that is microbiologically safe and wholesome.

Over the past decade, Safe Food Production Queensland (Safe Food) and the poultry meat industry have worked together to implement a purpose-built framework (the 'baseline model'), which facilitated a consistent reduction in quantities of *Campylobacter* and *Salmonella* on chicken carcases to below industry-agreed targets. Despite these positive outcomes, over the past six years the incidence of notified cases of campylobacteriosis in the Queensland community has risen dramatically. Whilst it remains unclear whether poultry meat is contributing to the observed changes in the epidemiology of campylobacteriosis in people in Queensland, we do know that in 2018/19 some processors were exceeding the agreed target for *Campylobacter* far more frequently than previously.

Safe Food verifies the effectiveness of food safety programs in controlling microbiological hazards associated with poultry meat through the processing chain. This regulatory function is carried out using a variety of regulatory tools, including periodic surveys of food safety system performance. In 2019, Safe Food conducted the present study to verify whether the baseline model was being effectively implemented. This study involved a microbiological survey of six chicken abattoirs in Queensland, which was conducted in conjunction with a regulatory audit.

The survey was designed to capture business processing parameters and carcase microbiological profiles at specific points through the production chain to determine the effectiveness of certain processes and interventions designed to control or reduce microbiological loads. Whole carcase samples were collected from each facility at three sampling points through-chain (post-evisceration, post-chilling and final product). Presence/absence of *Escherichia coli* was determined and quantification for *Campylobacter* spp., *Salmonella* spp., *E. coli*, coliforms and standard plate count (SPC) was performed. Data from Safe Food's electronic data-sharing platform (CIMS) was also used for comparative analysis with survey results.

Results of the survey suggested that poultry processing facilities are generally able to achieve the carcase-wash and immersion chilling targets set out in the baseline model. Further work is required for some facilities to consistently meet the target for feed-withdrawal, however. Other site-specific improvements, including prevention of unacceptable carcases entering the immersion wash, are expected to yield improved microbiological results.

Most facilities adequately reduced levels of *E. coli* and coliforms to below 'acceptable' levels, and in many cases, to levels that could be classified as 'excellent'. Good hygienic practices appear adequate in the majority of facilities, with most samples returning 'excellent' or 'good' results for SPC on final product. Data obtained from the present survey provides an avenue for exploring system hygiene improvements in two facilities that experienced an increase in SPC between post-chilling and final product points.

Salmonella is generally well managed through-chain, with most facilities achieving the industry target (≤ 100 MPN/carcase) for final product. Data extracted from CIMS suggests that the results obtained in the present survey are reflective of those obtained through internal monitoring programs, providing confidence in the validity of shared CIMS data.

In the 2019 survey, four out of six facilities were able to achieve geometric mean concentrations of *Campylobacter* on final product below the industry-agreed target (≤ 6,000 CFU/carcase). In 2012, nil poultry processing facilities were able to achieve this. Even so, only two facilities in the 2019 survey were able to consistently produce final product carcases with concentrations below the industry target, whilst all other facilities demonstrated greater variability in final product *Campylobacter* concentrations.

Compared to the 2012 Safe Food survey, poultry processing facilities in 2019 demonstrated substantially higher Campylobacter concentrations on carcases post-evisceration. Despite this, they also tended to achieve lower *Campylobacter* concentrations post-chilling and on final product. It is hypothesised that this is, in part, due to the success of baseline model framework and achievement of best practice washing and chilling targets. It's possible that the relatively higher *Campylobacter* concentrations observed post-evisceration are due to higher microbial populations in birds and significant increases in product throughput volumes. Whilst the improvement in final product results since 2012 demonstrates the advances industry has made, attention to reducing the initial loads of *Campylobacter* would alleviate the pressure placed on subsequent processing interventions. *Campylobacter* data submitted to Safe Food via CIMS were generally reflective of that obtained via the present survey.

The poultry meat and egg industries have made substantial progress to achieve a reduction in known food-borne pathogens. This has primarily been achieved using a baseline model approach to monitor performance. Survey and self-reported data support the notion that these

improvements, amongst other factors, have contributed to a marked reduction in salmonellosis notifications in recent times. Despite these improvements, this survey confirms the presence of *Campylobacter* in concentrations above the industry-agreed targets for some facilities. This demonstrates the need for enhanced monitoring and verification of control points through-processing. Gains may be observed by greater consistency in achieving the target for feed withdrawal (8 to 14 hours) and prevention of unacceptable carcases entering the wash. Further investigation should also be conducted into the effectiveness of on-farm measures for controlling *Campylobacter* populations. The ongoing effectiveness of the baseline model in controlling microbiological hazards associated with poultry meat relies on continued implementation of the model framework, producing stable food safety systems that yield consistent results.

The findings from this survey, in combination with a regulatory assessment, were able to assist industry to critically review areas of microbiological control and food safety importance and provide contemporary insights on the effectiveness of food safety controls implemented by Queensland poultry processors. As a result, conclusions drawn from the present study will further inform the ongoing regulatory discussion regarding poultry meat food safety and public health outcomes in Queensland.

Introduction

Campylobacter and *Salmonella* species are common causes of gastroenteritis in the Australian community. The majority of these cases are considered to be via foodborne transmission – in 2010, 77% of campylobacteriosis cases and 72% salmonellosis cases (Kirk *et al.* 2014). Whilst these organisms are associated with a variety of foods, they are routinely carried within the gastrointestinal tract of poultry and can contaminate meat (and meat products) during processing.

In Queensland, both campylobacteriosis and salmonellosis are notifiable diseases. During the year 2019, 9,152 cases of campylobacteriosis and 3,816 cases of salmonellosis were recorded for the State, representing the two most numerically significant gastrointestinal conditions observed (Queensland Health 2020). These two diseases represent a significant public health burden in terms of acute illnesses, post-infection complications and healthcare system pressure, costs borne by individuals and productivity losses (Kirk *et al.* 2014). The Australian Foodborne Illness Reduction Strategy 2018–2021+ was developed to reduce Australia's high case rates of campylobacteriosis and salmonellosis. Continued implementation of effective interventions, in addition to surveillance and monitoring programs, are crucial components of the strategy.

Under the requirements of both the Australian Standard for Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption (AS4465–2005) and Standard 4.4.2 of the Australia New Zealand Food Standards Code, microbiological hazards associated with poultry meat must be controlled through the processing chain to produce a product that is microbiologically safe and wholesome. As such, effective hazard management programs must be capable of identifying and addressing these food safety risks. Safe Food Production Queensland (Safe Food) verifies the effectiveness of these programs via the meat food safety scheme (*meat scheme*) under the Food Production (Safety) Regulation 2014.

Over the past decade, Safe Food and the poultry meat industry have worked together to implement a purpose-built framework (the 'baseline model') to facilitate greater and more consistent control of product hygiene. The driver of this collaboration was a joint desire to reduce the quantities of pathogens such as *Campylobacter* and *Salmonella* present on poultry meat processed in Queensland. The framework engenders control of key microbiological interventions by way of standardised procedures, concerted monitoring and the sharing of data in near-real time with Safe Food. Analyses and reporting performed by a common electronic platform (CIMS) allows this information to inform on-site decision-making. Compliance verification and ongoing monitoring of performance data has shown that the framework has facilitated a reduction in quantities of *Campylobacter* and *Salmonella* on

chicken carcases to below the agreed target values of 6,000 CFU/carcase and 100 MPN/carcase, respectively. In 2013, just a few short years after the framework was introduced, the incidence of notified cases of campylobacteriosis in the Queensland community fell to an 18-year low. The success of the framework is further reflected in its recent adoption as part of the national guidance on process hygiene control for poultry meat production, published by Food Standards Australia New Zealand (FSANZ) in the Compendium of Microbiology Criteria for Food.

Despite these positive outcomes, over the past six years the incidence of notified cases of campylobacteriosis in the Queensland community has risen dramatically (figure 1). Rates did appear to stabilise between 2015 and 2017, albeit at a record high level. Rates increased by a further 10% between 2017 and 2018. Furthermore, the number of cases reported by mid-2019 were 23% greater than the average for the same period of time over the preceding five years. This indicated that rates were continuing to climb.

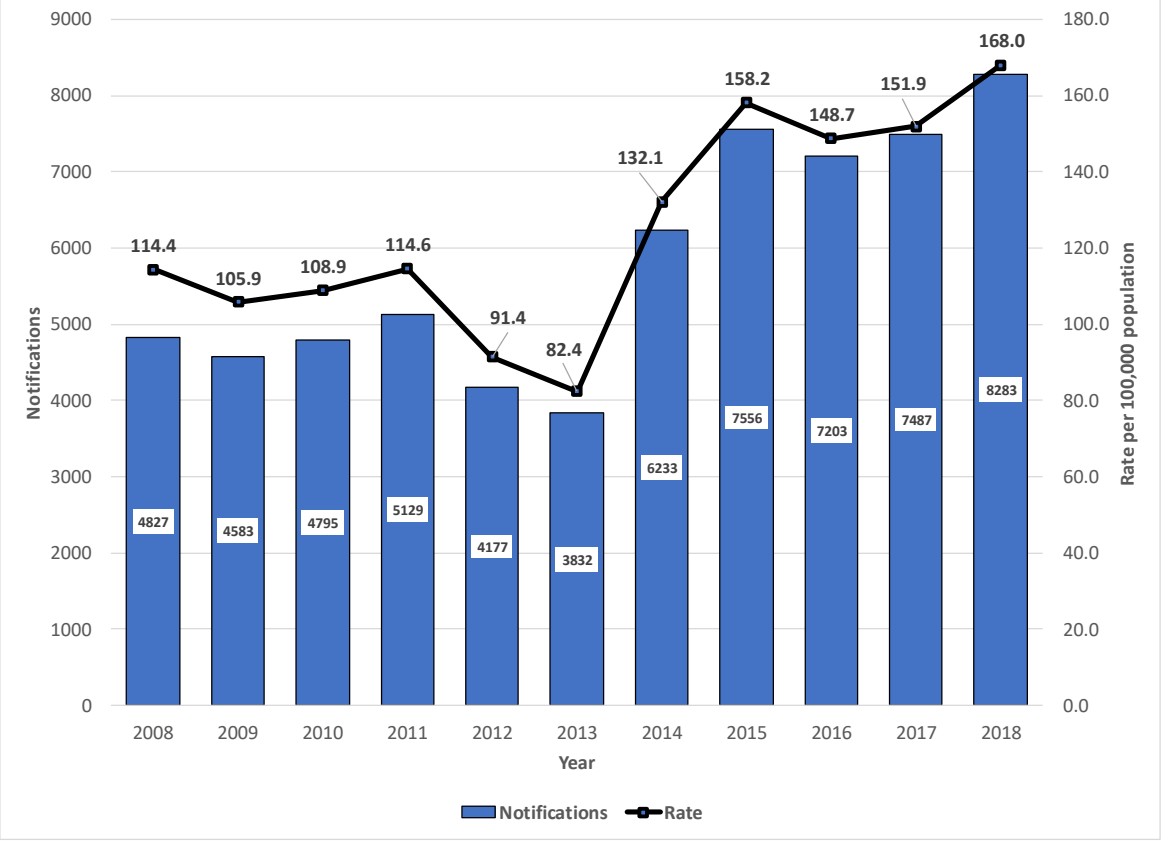

Figure 1: Campylobacter notifications and rates, Queensland by calendar year (provided by Communicable Diseases Branch, Queensland Department of Health).

It is likely that many factors have contributed to the drastic change in the incidence of notified cases of campylobacteriosis in the Queensland community. Foremost is the adoption by

testing laboratories of highly sensitive DNA-based technologies for diagnosing the causes of gastroenteritis. However, this does not appear to explain the surge in case numbers observed in 2018 and 2019.

It remains unclear whether poultry meat is contributing to the observed changes in the epidemiology of campylobacteriosis in people in Queensland. Microbiological data submitted to Safe Food has shown that throughout 2018/19 some processors were exceeding the agreed target for *Campylobacter* far more frequently than the preceding year. In some cases, the quantities of *Campylobacter* per carcase have been many orders of magnitude greater than 6,000 CFU/carcase.

The majority (> 90%) of poultry meat in Queensland is processed using highly mechanised and automated equipment. The system relies on constant monitoring and adjustment to equipment to cater for variations in flock sizes as well as manual back-up operations to deal with contaminated or unacceptable carcases. Nuanced farming management practices may also influence the microbial ecology within farming environments and within birds. For example, the attainment of RSPCA certification in 2012 for many production systems has led to changes in stocking densities and litter management on-farm. It is not well-understood how these and other changes in farming practices have influenced microbial populations, however. Another change within the industry since previous Safe Food surveys includes the closure of a major processing facility in South East Queensland in 2018. This closure has generated new poultry meat supply chains and augmented existing distribution channels.

Safe Food performed the present study to verify whether the baseline model framework was being effectively implemented. This study involved a survey of six chicken abattoirs in Queensland, given that the incidence of illness was consistently high across all Queensland regions. The survey was designed to capture business processing parameters and carcase microbiological profiles at specific points through the production chain. The study aimed to determine the effectiveness of certain processes and interventions designed to control or reduce microbiological loads by:

- Assessing the compliance of Queensland poultry processors with the Food Production (Safety) Regulation 2014 and AS4465–2005.
- Providing data on the prevalence and levels of *Salmonella* and *Campylobacter* on chicken meat at primary processing stages of the chicken meat supply chain.
- Providing data on the effectiveness of existing hygiene controls during production using enumeration of SPC, *E. coli* and coliforms as indicators of process control.
- Reviewing the ongoing effectiveness of *Salmonella* and *Campylobacter* reduction strategies.

- Identifying any correlation between Queensland human health data for *Salmonella* and *Campylobacter* and chicken meat processed in Queensland.

This study forms part of Safe Food's schedule of verification activities that contribute to the ongoing evaluation of food safety schemes. This study builds on the achievements of previous system verification surveys completed by Safe Food in 2008, 2012 and 2015 and complements a multi-state study of *Campylobacter* prevalence in retail chicken products completed by Walker *et al.* (2019).

Methods

Survey participants and business profile

The survey was conducted in six accredited poultry processing facilities, representing more than 90% of poultry meat produced in the state of Queensland. All businesses included in the survey processed chicken meat (broiler or hen) only; processors of quail, squab or other types of poultry meat were not included. All facilities surveyed were considered large- to medium-scale businesses, encompassing a variety of production systems including conventional, organic and free-range. Many commonalities exist between facilities; however, each is unique in the design and configuration of processing lines. Furthermore, some facilities are exclusive in the use of specific washing procedures or chilling processes. Whilst these differences may explain some nuances in the observed results, the legislative food safety requirements of the *meat scheme* remain consistent.

For each facility, the following business profile information was collected to contextualise results:

- Product types and volumes
- Supply and distribution patterns
- Average processing line speed for week prior to sampling

Baseline model targets

Compliance audits completed at the time of survey considered each businesses' awareness of, provision for, and commitment to a range of food safety principles and legislative requirements. The compliance audits also assessed businesses' monitoring and management of food safety control points, verification points and the achievement of the industry-agreed processing targets. These targets are summarised in table 1.

Table 1: Verification points and performance targets of the baseline model for poultry meat in Queensland

Verification point	Target
Live bird receipt	Feed withdrawn within 8 to 14 hours prior to commencement of slaughter
Evisceration	Nil unacceptable carcases to proceed from evisceration line to wash/chill tanks
Washing and chilling	Wash and chill water to be maintained at: • < 4°C • pH 5 to 6.5 • > 5 ppm free available chlorine (FAC) or 650mV oxidation reduction potential (ORP) measured at chiller overflow point.
Storage	Core carcase temperature to be maintained at ≤ 5°C *Campylobacter* ≤ 3.78 log10 CFU (6,000 CFU) per final-product carcase *Salmonella* ≤ 2.0 log10 MPN (100 MPN) per final-product carcase

Sample collection

Carcase samples were collected from each facility on one occasion only (except for facility G). The date of sample collection differed for each business, coinciding with the date of a regulatory compliance audit during the period 1 September 2019 and 31 December 2019.

For each facility, whole carcase samples were collected as follows:

- 3 x carcases – post-evisceration, prior to inside/outside washing
- 3 x carcases – after the chilling process and prior to grading (i.e. upon exit from immersion-chilling or air-chilling equipment)
- 3 x carcases – at the final point of packing (final product)

This yielded 9 samples per facility (for facilities A, B, D, E & F), whilst additional samples were collected from facility G. Samples from facility G were taken across two different processing cohorts. As such, a total of 63 carcase samples were collected for the survey:

- Facility A (*n* = 9)
- Facility B (*n* = 9)
- Facility D (*n* = 9)
- Facility E (*n* = 9)
- Facility F (*n* = 9)
- Facility G (*n* = 18)

The precise position of each point was stipulated by each facility as suitable to comply with workplace health and safety considerations.

Samples at each point were collected at random and in quick succession. Each carcase was handled and packaged aseptically, uniquely and confidentially identified, placed on ice and transported under temperature control to a NATA-accredited commercial testing laboratory for microbiological analysis. Carcases deemed to be quality downgrades (e.g. broken wings, bruising etc.) were not excluded from selection. Sampling was conducted so that all carcases obtained for analysis were from the same flock and processing cohort (except facility G). Only older birds (i.e. birds > 2.5kg) were collected for analysis, as older birds and those collected from flocks that had been previously thinned were more likely to be associated with greater *Campylobacter* prevalence and thus more accurately reflect worse-case scenario (Sibanda *et al.* 2018).

For each sample, the following information was collected:

- Current line speed and average line speed for previous week
- Flock downgrade percentage
- Average live weight
- Feed withdrawal time
- Grower and shed identification
- Age of birds
- Carcase-wash and immersion chiller data (FAC, pH, water temperature)
- Time of collection

Laboratory and statistical analyses

Temperature and weight of carcase samples were recorded upon receipt to the laboratory. Carcases were rinsed with 500mL buffered peptone water and analysed for enumeration of *Campylobacter* spp., *Salmonella* spp., *Escherichia coli*, coliforms and standard plate count (according to AS1766.2.13-1991, AS5013.20-2004, AOAC991.14, AOAC991.14, and AOAC 990.12 respectively). Presence/absence of *E. coli* per sample was also determined using AS5013.9-BAM4.

Results were reported as the number of colony forming units per square centimetre (CFU/cm^2) and per carcase (CFU/carcase) or most probable number of cells per carcase (MPN/carcase).

Carcase weights were converted to carcase surface area using the following equation:

Carcase surface area (cm^2) = 0.87(*w*) + 635

Where *w* = carcase weight in grams

The test sensitivities for the above methods based on the number of dilutions performed were described with the following Limits of Reporting (LOR):

- *Salmonella*: 65 MPN/carcase
- *Campylobacter*, *E. coli*, coliforms: 5,000 CFU/carcase
- Standard plate count: 50,000 CFU/carcase

For the purposes of analysing results reported as being below the LOR, the LOR figure was halved ($\frac{\text{LOR}}{2}$) and the quotient used as a figure for the analysis.

E.g. *Salmonella* <65 MPN/carcase → ($\frac{65\ \text{MPN/carcase}}{2}$) = 32.5 MPN/carcase.

Results were also converted to $\log_{10}$ scale for graphical presentation and discussion.

E.g. 6,000 CFU ≈ 3.78 $\log_{10}$ CFU

10,000 CFU = 4 $\log_{10}$ CFU

The number of samples collected during this study was relatively small. This precluded the use of inferential statistics as the power of such analyses would have been limited. Instead, descriptive statistics were used, including proportions, geometric means, absolute and relative differences, ranges, as well as minimum and maximum values. For statistics calculated at the 'survey' level, results from each facility were weighted based on the average number of birds processed per week, in 2019, 2015 and 2012 respectively.

All data was collated and analysed in Microsoft Excel 365.

Results & discussion

Processing parameters

Analyses of results did not indicate any obvious or direct correlation between bird age, line speed, flock downgrade percentage and microbiological results. These factors are important correlates; however, the lack of an obvious pattern is likely due to the significant interactive effects of other confounding factors (e.g. effectiveness of processing equipment, initial microbial populations in birds) that were not controlled for in the survey.

Data obtained via the survey and CIMS indicates that most facilities consistently achieve the baseline model targets for immersion washing/chilling. Areas for improvement were identified however, and include the following:

- One facility is unable to achieve the immersion chilling water temperature target consistently and is working with Safe Food under a corrective action plan.
- Some facilities have difficulty in consistently achieving feed withdrawal targets due to the location of production farms and logistical constraints associated with supply.
- Carcase measurements taken during audits showed that unacceptable carcases progressed from the evisceration line to the immersion wash in some facilities.

These observations provide a starting point for actions that may yield improved microbiological results.

Campylobacter spp.

Post-evisceration

Analysis of post-evisceration samples from all facilities generated a 'survey' weighted geometric mean concentration of 6.23 $\log_{10}$ CFU/carcase for *Campylobacter* spp. (figure 2). As described in the methods, 'survey' values are calculated using a weighting assigned to each facility based on the average number of birds processed per week by each facility. There was a high degree of variability in carcase *Campylobacter* concentrations between facilities and within some facilities (figure 3). Facility F consistently returned high concentrations of *Campylobacter* post-evisceration (geometric mean = 6.47 $\log_{10}$ CFU/carcase), whilst facility G had similarly high concentrations at this sampling point (geometric mean = 6.46 $\log_{10}$ CFU/carcase). Facility D recorded the lowest concentration of *Campylobacter* on post-evisceration samples (geometric mean = 4.18 $\log_{10}$ CFU/carcase), however there was a high degree of variability (range = 1.9 $\log_{10}$ CFU/carcase) between individual post-evisceration samples for this facility.

Post-immersion or post-air chilling

Based on samples collected during this survey, the 'survey' weighted geometric mean *Campylobacter* concentration for carcases post-immersion or post-air chilling was 3.80 $\log_{10}$ CFU/carcase. At this sampling point, facilities A and G achieved geometric mean concentrations below 3.78 $\log_{10}$ CFU/carcase, whereas geometric mean concentrations on carcases from facilities B and D were above 5 $\log_{10}$ CFU/carcase. Sample results from facility B ranged widely, from below the LOR (3.70 CFU/carcase) to 5.93 $\log_{10}$ CFU/carcase.

Final product

FSANZ guidelines (FSANZ 2018) set a process control target for *Campylobacter* of 4 $\log_{10}$ CFU/carcase at the end of processing. In late 2015, the Queensland poultry processing industry voluntarily opted to lower the target for *Campylobacter* on final product from 4 $\log_{10}$ CFU/carcase (10,000 CFU/carcase) to 3.78 $\log_{10}$ CFU/carcase (6,000 CFU/carcase). This target aligns with the figure for regulatory enumeration targets set in New Zealand, which is based on a moving window of compliance (NZFSCRMSWG 2019). The Queensland target is a constant food safety performance target agreed to by Safe Food and industry. The moving window concept is not a formal aspect of the Queensland target.

Microbiological analyses of final product samples for the present survey revealed that four out of the six facilities surveyed were able to achieve geometric mean concentrations of *Campylobacter* below the industry-agreed target. Of the total final product samples collected, 71% were below the industry target for *Campylobacter*. Collated final product data from across all facilities yielded a 'survey' weighted geometric mean *Campylobacter* concentration of 3.57 $\log_{10}$ CFU/carcase.

Only two facilities (A and G) were able to consistently produce final product carcases with concentrations below the industry target. For facilities B, E and F, one in three samples obtained for each plant had counts in excess of the industry target, whilst sample results for facility D were consistently above the target. It should be noted that the samples obtained from facility D were destined for freezing, further processing and heat treatment. The range of final product results for facilities D and F was noticeably larger than that of other facilities, suggesting that systems in these plants are not delivering consistent results. The highest observed *Campylobacter* result for final product was 5.15 $\log_{10}$ CFU/carcase (facility F). Nil results were in the range of 3.78 – 4 $\log_{10}$ CFU/carcase.

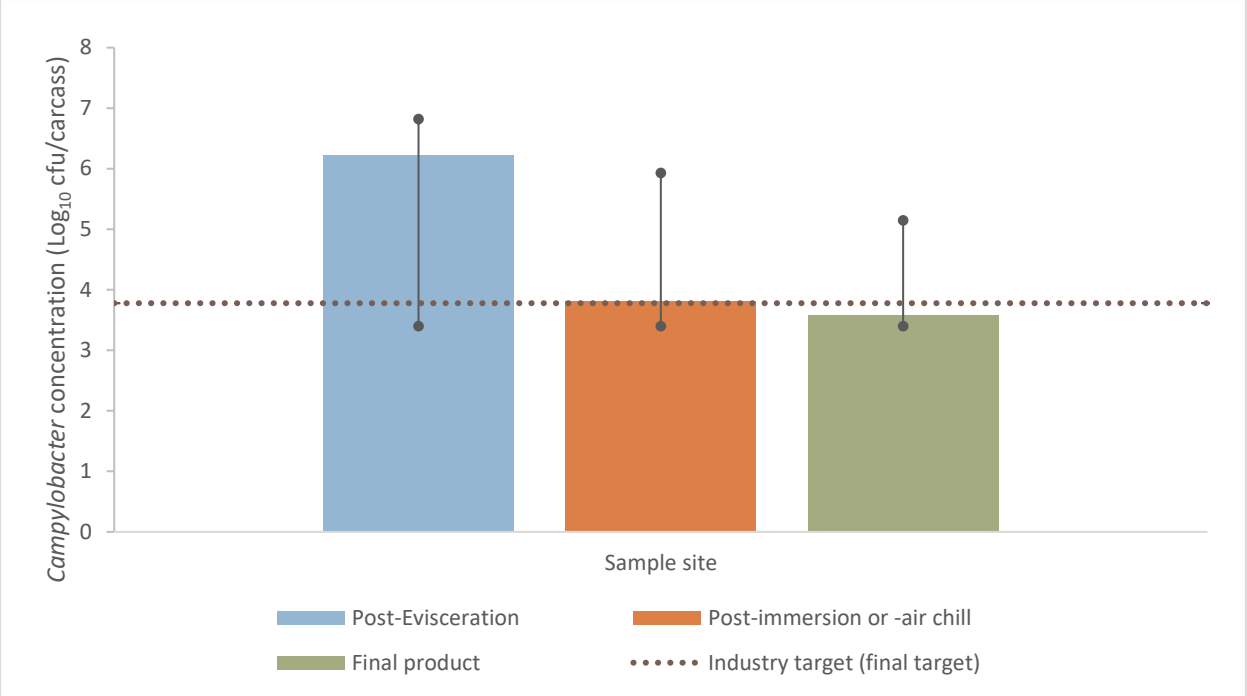

Figure 2: 'Survey' concentrations of *Campylobacter* (log_{10} CFU/carcase) sampled on carcases at three points through-chain. Coloured bars indicate weighted geometric mean *Campylobacter* concentration for the sampling site based on aggregated data from all facilities; range bars indicate maximal and minimal detected counts.

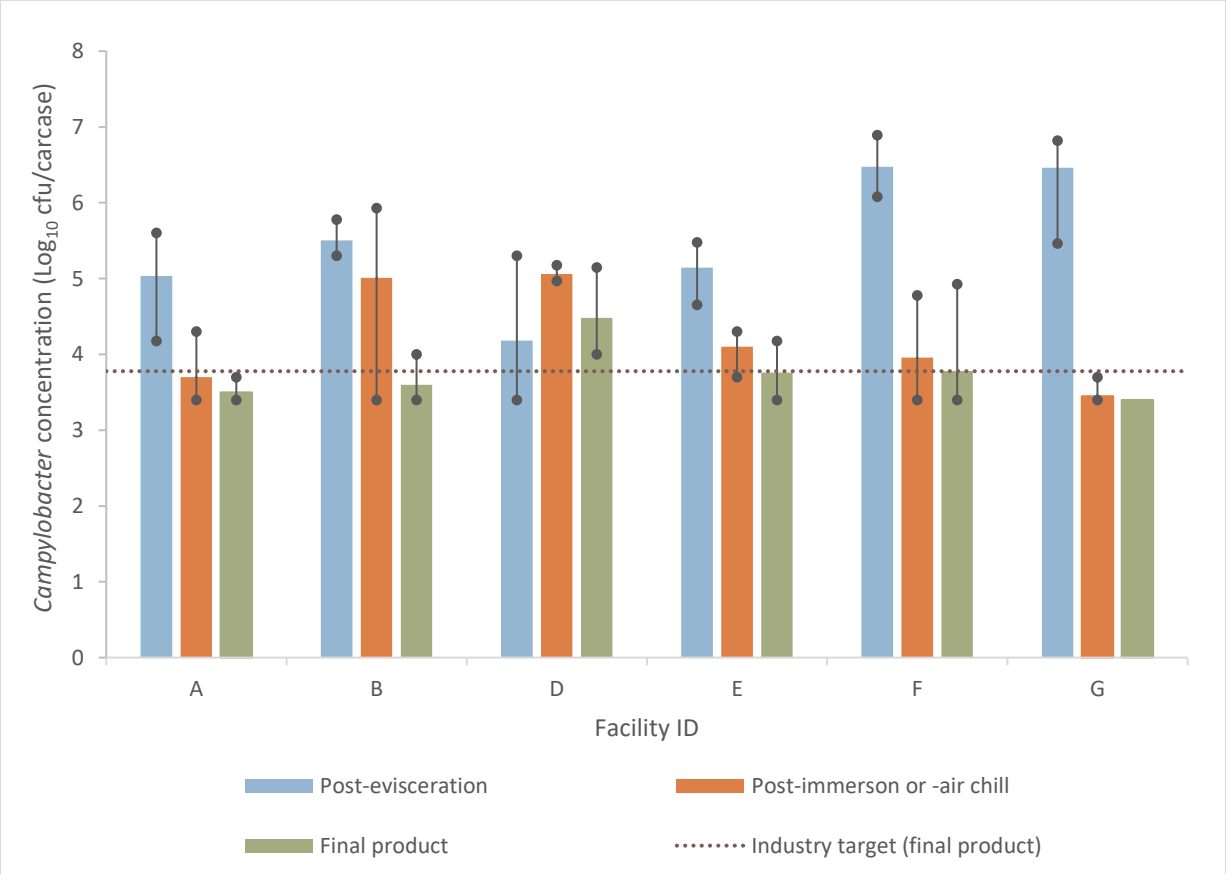

Figure 3: Distribution of *Campylobacter* concentrations (log_{10} CFU/carcase) sampled on carcases at three points through-chain for all facilities. Coloured bars indicate geometric mean *Campylobacter* concentration for the sampling site; range bars indicate maximal and minimal detected counts.

Reduction through-chain

All facilities (except facility D) demonstrated a reduction in geometric mean *Campylobacter* concentrations on carcases through-chain greater than 1.3 $\log_{10}$ CFU/carcase (table 2). The apparent increase in *Campylobacter* concentrations through chain for facility D could be due to configuration of chilling equipment and wide variability in microbial populations of birds.

The marked decrease in geometric mean *Campylobacter* concentrations between post-chilling and final product points for facility B requires further examination. Given the lack of significant process intervention steps between the two points, the apparent reductions calculated reflect the high variability in carcase results post-chilling at this facility. The cause of this inconsistency in carcase microbiological results will provide a discussion point and route of investigation for this facility.

Two facilities (F and G) had the highest geometric mean concentration post-evisceration. In general, both were able to achieve a substantial reduction in concentrations through chain. Facility G however, had a relatively larger and more consistent reduction in *Campylobacter* concentrations through-chain (to below the target) compared to facility F.

Facility F had one of the highest processing line speeds of all facilities surveyed. Facility B had line speeds commensurate with facility G and processed birds of a similar age, yet the geometric mean *Campylobacter* concentration post-chilling for facility B was 5.01 $\log_{10}$ CFU/carcase, compared to 3.45 $\log_{10}$ CFU/carcase for facility G. Whilst line speed remains a factor of interest, its effects were confounded with several other factors not controlled for in this survey.

2015 Safe Food system verification survey

The results from the present survey generally reflect those of the 2015 Safe Food microbiological verification survey, which assessed product from twelve Queensland poultry processing facilities. A point of difference, however, is the highest observed final product results in 2015 were at least 1 $\log_{10}$ CFU/carcase higher than those observed in the 2019 survey. These results (> 6 $\log_{10}$ CFU/carcase) were observed in samples taken from two different facilities. Only one of these two facilities were included in the 2019 survey. The number of replicate samples taken during the 2015 survey were limited. For this reason, data from the 2015 survey will not be discussed further in this report.

2012 Safe Food system verification survey

The 2012 Safe Food microbiological verification survey was more similar in design to the present survey than that of 2015.

In Safe Food's 2012 microbiological line survey, weighting of post-evisceration sample results from all facilities generated a 'survey' geometric mean of 5.01 $\log_{10}$ CFU/carcase, whereas in 2019 this figure was 6.23 $\log_{10}$ CFU/carcase result (table 3 – page 17). This difference is largely attributable to the relatively higher post-evisceration results at facilities F and G in 2019. It's possible that this apparent increase in post-evisceration concentrations compared to 2012 may be due to a higher prevalence of *Campylobacter* in some flocks and significant increases in product throughput volumes. These areas of discussion will be investigated further with specific facilities.

A FSANZ study in 2010 reported a mean concentration of 4.83 $\log_{10}$ CFU/carcase for final product in Queensland facilities (FSANZ 2010). In 2012, final product results from samples taken across eight processing facilities generated a weighted geometric mean *Campylobacter* concentration of 4.24 $\log_{10}$ CFU/carcase. This statistic in the 2019 survey was 3.57 $\log_{10}$ CFU/carcase.

In 2012 only one of the eight facilities surveyed consistently obtained carcase results for *Campylobacter* below the industry target (which was 4 $\log_{10}$ CFU/carcase in 2012); this facility was not included in the 2019 survey. The 2012 survey also revealed that two facilities (included in the 2019 survey) experienced an increase in the number of *Campylobacter* cells between carcase washing and final product. In the 2019 survey, all six facilities demonstrated stable concentrations of *Campylobacter* between post-chilling and final product collection.

Comparing the data in table 3, it is evident that some facilities are starting with more numerous *Campylobacter* cells per carcase post-evisceration in 2019 than 2012. For facilities F & G, the 2019 values are approximately 1.5 $\log_{10}$ CFU/carcase greater than in 2012. The majority of facilities also demonstrate a greater capacity to reduce *Campylobacter* concentrations during primary processing in 2019 than in 2010 or 2012. However, as a general pattern, compared to 2012, the 2019 processing systems were producing higher starting concentrations of *Campylobacter* cells post-evisceration, and delivering lower concentrations of *Campylobacter* cells on final product. Whilst the 2019 result is favourable when compared to 2012, the generally higher starting concentrations of *Campylobacter* may be placing more pressure on decontamination points to achieve the desired reduction.

In the 2012 survey, the change in geometric mean concentration of *Campylobacter* on carcases at facility D between post-evisceration and final product collection changed little

(-0.04 $\log_{10}$ CFU/carcase). This trend was still evident in the 2019 survey (-0.30 $\log_{10}$ CFU/carcase). Facility D was also the only processor in the present survey to show an increase in carcase *Campylobacter* counts between post-evisceration and post-chilling. It's possible that the trend observed at this facility is due to the configuration of carcase chilling equipment. It should be noted that the product line sampled at this facility was subject to be further processing steps. Nevertheless, the range of results for post-evisceration samples from facility D was large and warrants further investigation to establish clear patterns.

Table 2: Reduction of *Campylobacter* concentrations and achievement of industry target for final product (≤ 6,000 CFU/carcase in 2019; ≤ 10,000 CFU/carcase in 2012) for all facilities. † Values for $\log_{10}$ reduction in concentrations were calculated from the difference between geometric means ($\log_{10}$ CFU/carcase) of post-evisceration samples and final product samples. CIMS data (n = 616) for final product *Campylobacter* concentrations from the period 1 September 2019 to 31 December 2019 has been tabulated for comparison with final product results in the 2019 survey. Final product results from Safe Food's 2012 survey has also been tabulated for comparison with 2019 data.

	2019 survey			2019 CIMS	2012 survey
Facility	Reduction in *Campylobacter* concentrations between post-evisceration and final product †	Geometric mean concentration achieves industry target	% final product samples achieve industry target	% of CIMS results achieve industry target	Geometric mean concentration of 2012 survey samples achieve 2012 industry target
A	1.54	✓	100%	100%	×
B	1.90	✓	66%	66.7%	×
D	-0.30	×*	0%*	91.1%	×
E	1.39	✓	66%	100%	×
F	2.69	✓	66%	73.2%	×
G	3.06	✓	100%	99.4%	×

*Product line subject to further processing, survey sample site different to CIMS sample site.

Table 3: Comparison of geometric mean *Campylobacter* concentrations (log_{10} CFU/carcase) on carcases at three sampling points through-chain for all facilities in the 2019 and 2012 surveys. † Values for log_{10} reduction in concentrations were calculated from the difference between geometric means of post-evisceration samples and geometric means of final product samples.

	Post-evisceration (*Campylobacter* log_{10} CFU/carcase)		**Post-immersion or air chill** (*Campylobacter* log_{10} CFU/carcase)		**Final product** (*Campylobacter* log_{10} CFU/carcase)		**Reduction in *Campylobacter* concentrations** (log_{10} CFU/carcase) between post-evisceration and final product †	
Facility	2019	2012	2019	2012	2019	2012	2019	2012
A	5.03	6.19	3.70	4.62	3.50	4.45	1.54	1.74
B	5.50	5.02	5.01	4.41	3.60	4.33	1.90	0.68
D	4.18	4.60	5.06	4.32	4.48	4.54	-0.30	0.06
E	5.14	5.03	4.10	4.30	3.76	4.19	1.39	0.84
F	6.47	4.91	3.96	4.54	3.78	4.56	2.69	0.35
G	6.46	5.01	3.45	3.96	3.40	3.91	3.06	1.11
'Survey' weighted geometric mean	6.23	5.10	3.80	4.35	3.57	4.32		

Safe Food's electronic data sharing platform (CIMS)

Figure 4 illustrates final product *Campylobacter* data submitted via CIMS for the facilities that participated in the present survey. This data extract relates to the 1 September 2019 to 31 December 2019 period.

Based on the limited number of samples collected in the present survey, the results are generally comparable with the CIMS data. There are some differences to note, however. A higher proportion of survey samples (29%) were found to contain *Campylobacter* concentrations greater than the industry target; whereas the CIMS data suggests 14% of final product samples exceeded the industry target (figure 5). The reason for this difference may be due to a variety of reasons.

The number of *Campylobacter* data points (n = 616) submitted by the facilities in question via CIMS is far greater than that of the survey and should provide a better estimation of actual prevalence on final product. On the other hand, for the CIMS data, some variation in sampling methodologies (e.g. location, bird size, bird age, product grade) and sampling rates may affect a comparison with survey data. For facility D, for example, the sample site used in the survey did not align with that used for CIMS data collection. Furthermore, larger facilities supply a far greater number of microbiological data points, skewing direct comparisons between survey and CIMS data percentages. Safe Food will continue to verify that data is being collected and entered accurately prior to submission and translated effectively via the middleware.

2019 retail survey in three Australian States

A recent survey by Walker *et al.* (2019) *on* the prevalence of *Campylobacter coli* and *Campylobacter jejuni* in retail chicken products from Queensland, New South Wales and Victoria found that 9% of whole bird carcases had *Campylobacter* spp. concentrations > 4 $\log_{10}$ CFU/carcase. In the current survey, final product samples from processing facilities with concentrations > 4 $\log_{10}$ CFU/carcase equated 29%. As the retail survey took place across three jurisdictions, the influence of product results from facilities outside the scope of the Safe Food survey is expected. Some facilities surveyed by Safe Food also supply a greater proportion of retail products, whilst other facilities concentrate on supplying further processed products rather than portion or whole bird products. As such, direct comparisons become difficult. Interestingly, CIMS data shows that 10.5% of final product results for *Campylobacter* are > 4 $\log_{10}$ CFU/carcase. Whilst several uncontrolled factors (particularly facility of origin) are likely to vary between the retail survey data and CIMS data, the similarity in results between surveys is worth noting.

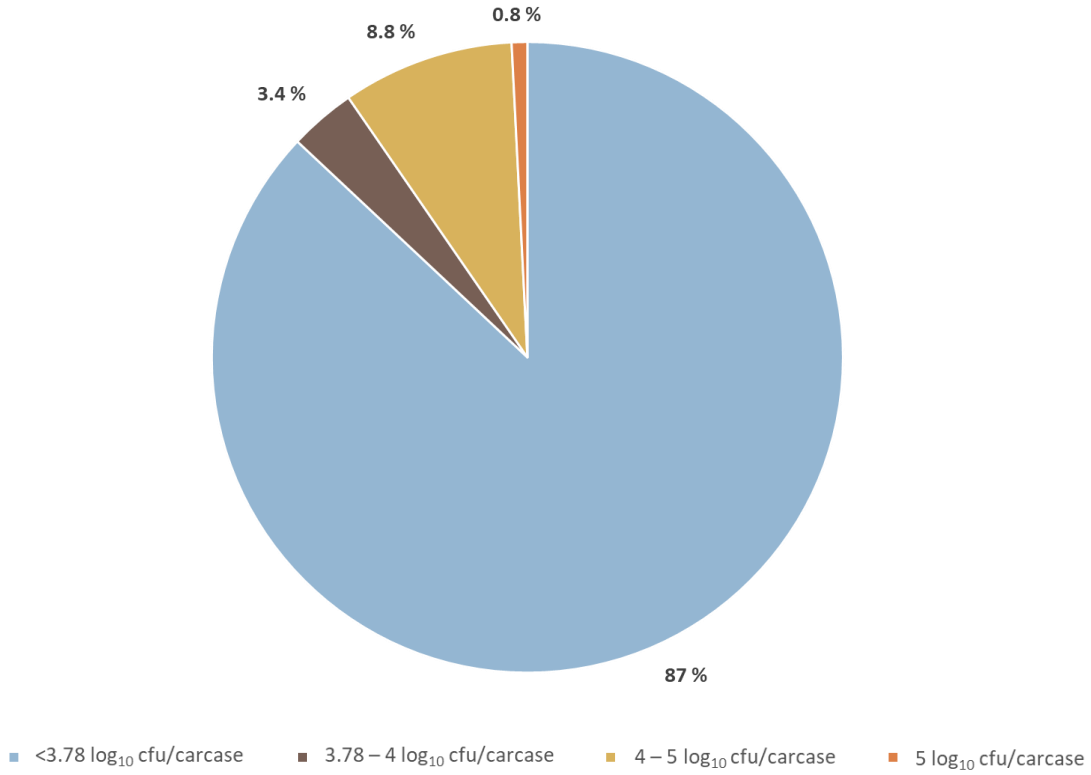

Figure 4: Categorical distribution of 2019 *Campylobacter* results for final product data (*n* = 616) submitted by facilities A, B, D, E, F & G via Safe Food CIMS. These results relate to data submitted for the period 1 September 2019 to 31 December 2019.

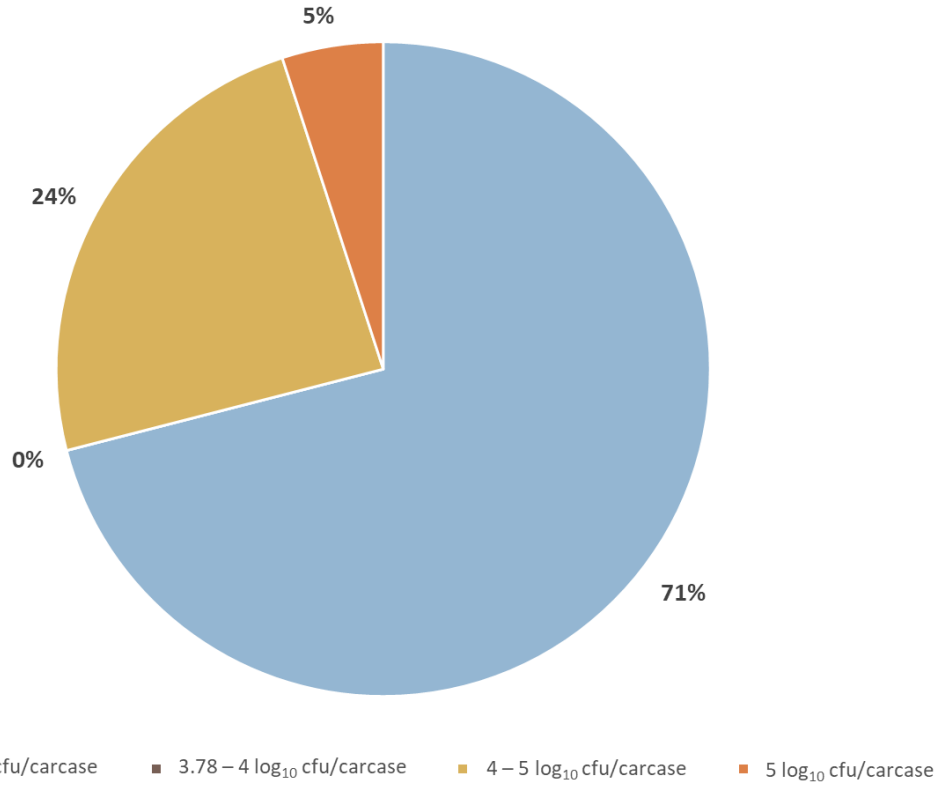

Figure 5: Categorical distribution of *Campylobacter* results for final product samples (*n* = 21) collected from facilities A, B, D, E, F & G during the 2019 Safe Food microbiological verification survey period.

Salmonella spp.

Results from the present survey suggest that for most facilities *Salmonella* is well managed through-chain (figure 4). All facilities (except Facility A) were able to achieve consistently achieve the industry target of ≤ 100 MPN/carcase for final product (figure 5). Facility A demonstrated greatest variability in results, particularly post-evisceration (post-evisceration range: 32.5 to 29,600 MPN/carcase). Higher counts associated with this facility may be partially due to the nature of production systems from which the birds originate.

Data extracted from CIMS (*n* = 651) suggests that the results obtained in the present survey are reflective of those obtained through internal monitoring programs (table 4).

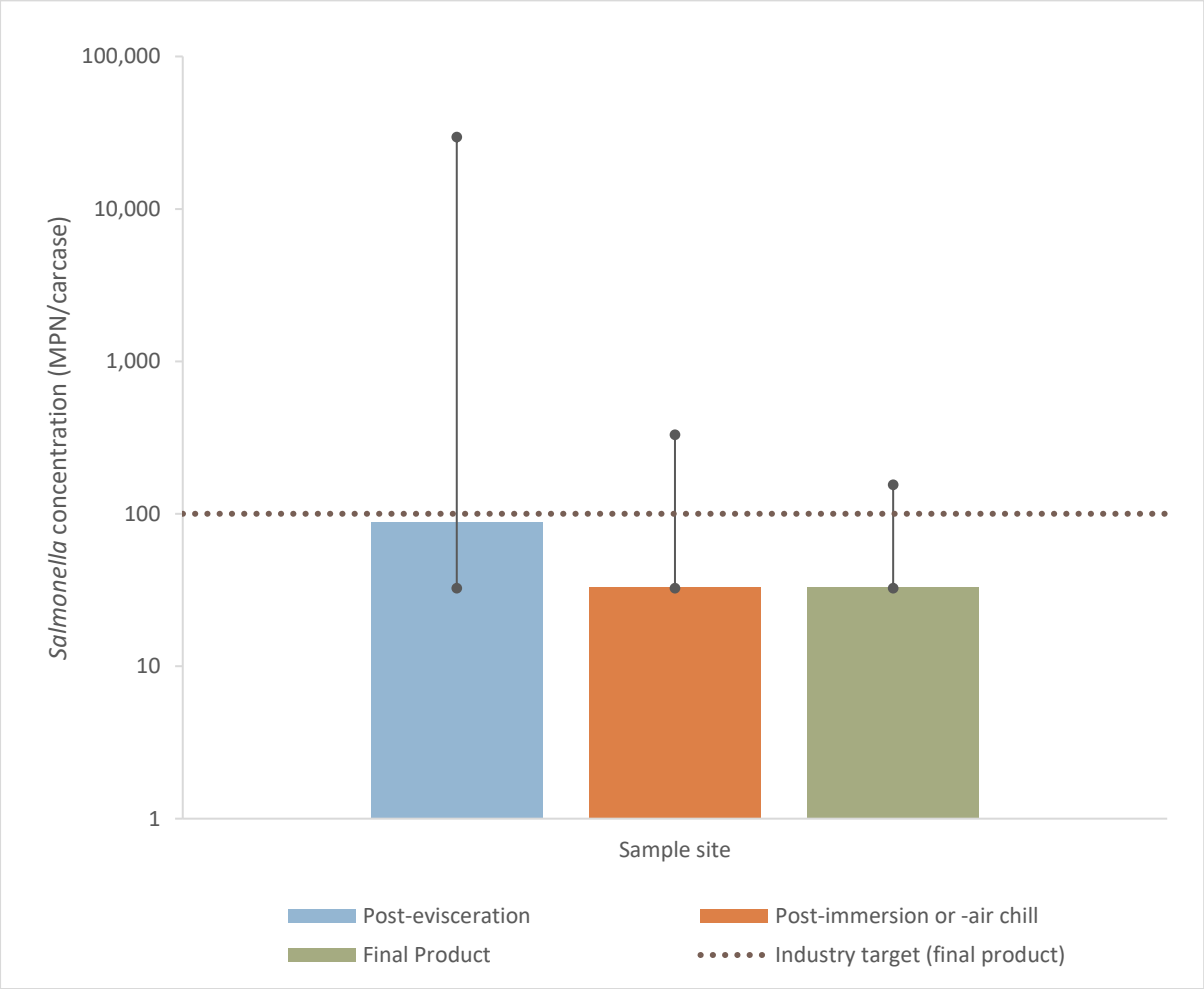

Figure 4: 'Survey' concentrations of *Salmonella* (MPN/carcase) sampled on carcases at three points through-chain. Coloured bars indicate weighted geometric mean *Salmonella* concentration for the sampling site based on aggregated data from all facilities; range bars indicate maximal and minimal detected counts.

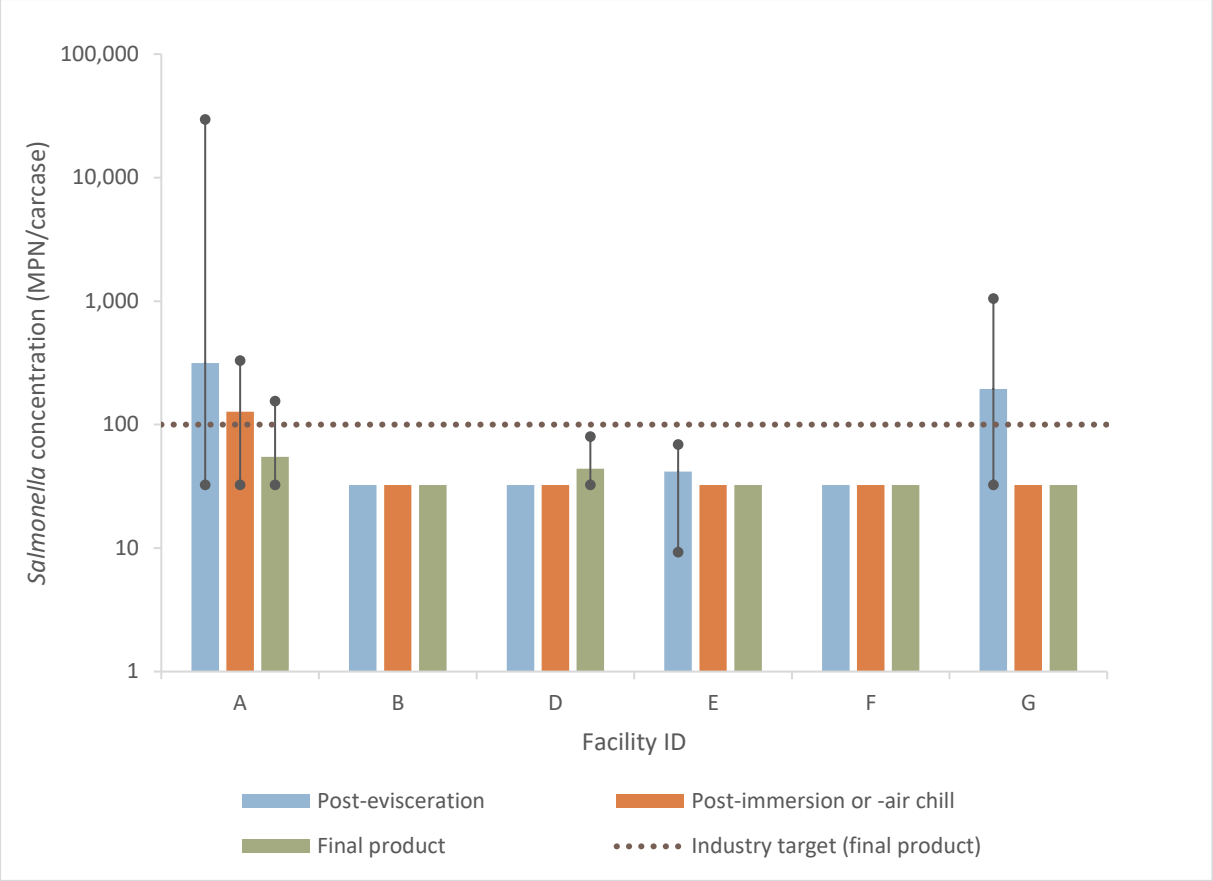

Figure 5: Distribution of *Salmonella* concentrations (MPN/carcase) sampled on carcases at three points through-chain for all facilities. Coloured bars indicate geometric mean *Salmonella* concentration for the sampling site; range bars indicate maximal and minimal detected counts.

Table 4: Achievement of industry target for *Salmonella* on final product (≤ 100 MPN/carcase) for all facilities. CIMS data (*n* = 651) for final product *Salmonella* concentrations from the period 1 September 2019 to 31 December 2019 has been tabulated for comparison with final product results in the survey.

Facility	Geometric mean concentration achieves target for final product	% final product samples achieve industry target	% of CIMS results achieve industry target
A	✓	66%	100%
B	✓	100%	100%
D	✓	100%	96.4%
E	✓	100%	100%
F	✓	100%	99.5%
G	✓	100%	99.4%

Escherichia coli and coliforms

E. coli was detected on 100% of post-evisceration samples, 95% of post-chilling samples and 86% of final product samples.

Survey data suggests that most facilities adequately reduced levels of *E. coli* and coliforms to below 'acceptable' levels, and in many cases, to levels that could be classified as 'excellent' (table 5; figures 6 & 7). Facility D samples, however, showed concentrations staying consistent or even increasing through-chain, whilst remaining within the 'good' range.

The results for facilities F & G support earlier observations of possible higher initial microbial populations within birds.

With the exception of facility D, there did not appear to be any substantial increase in *E. coli* or coliform concentrations between chilling and final product points for other facilities.

The highest result for both *E. coli* and coliforms on final product was 5.30 $\log_{10}$ CFU/carcase (facility D).

It should be noted that the testing of *E. coli* and coliforms at the end of processing does not necessarily provide good indicators of the likelihood of poultry becoming contaminated with *Campylobacter* or *Salmonella* (FSANZ 2010; Lindblad *et al.* 2006).

Table 5: Performance categories for *E. coli* on chicken meat (based on criteria adapted from Sumner *et al.* 2004; FSANZ 2010)

Category descriptor	***E. coli* ($\log_{10}$ CFU/carcase)**
Excellent	< 4.4
Good	4.4 - 5.4
Acceptable	5.4 - 6.4
Marginal	> 6.4

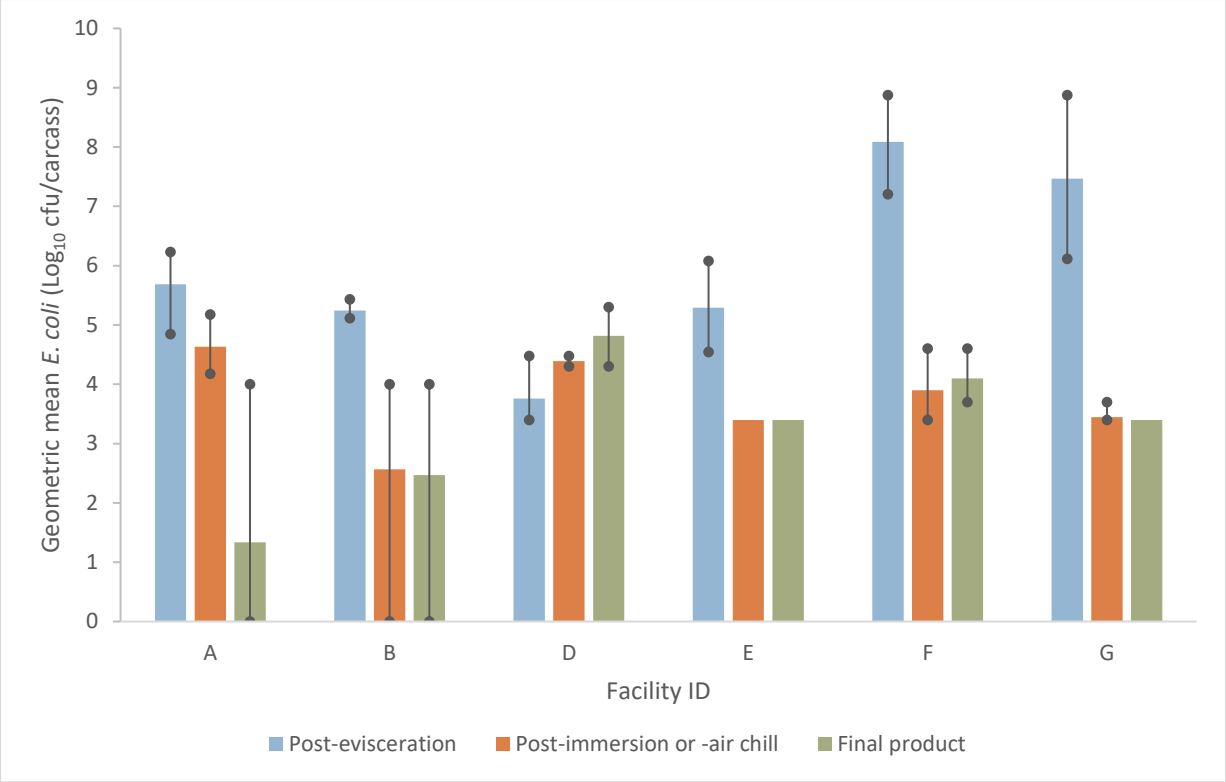

Figure 6: Distribution of *E. coli* concentrations (log_{10} CFU/carcase) sampled on carcases at three points through-chain for all facilities. Coloured bars indicate geometric mean *E. coli* concentration for the sampling site; range bars indicate maximal and minimal detected counts.

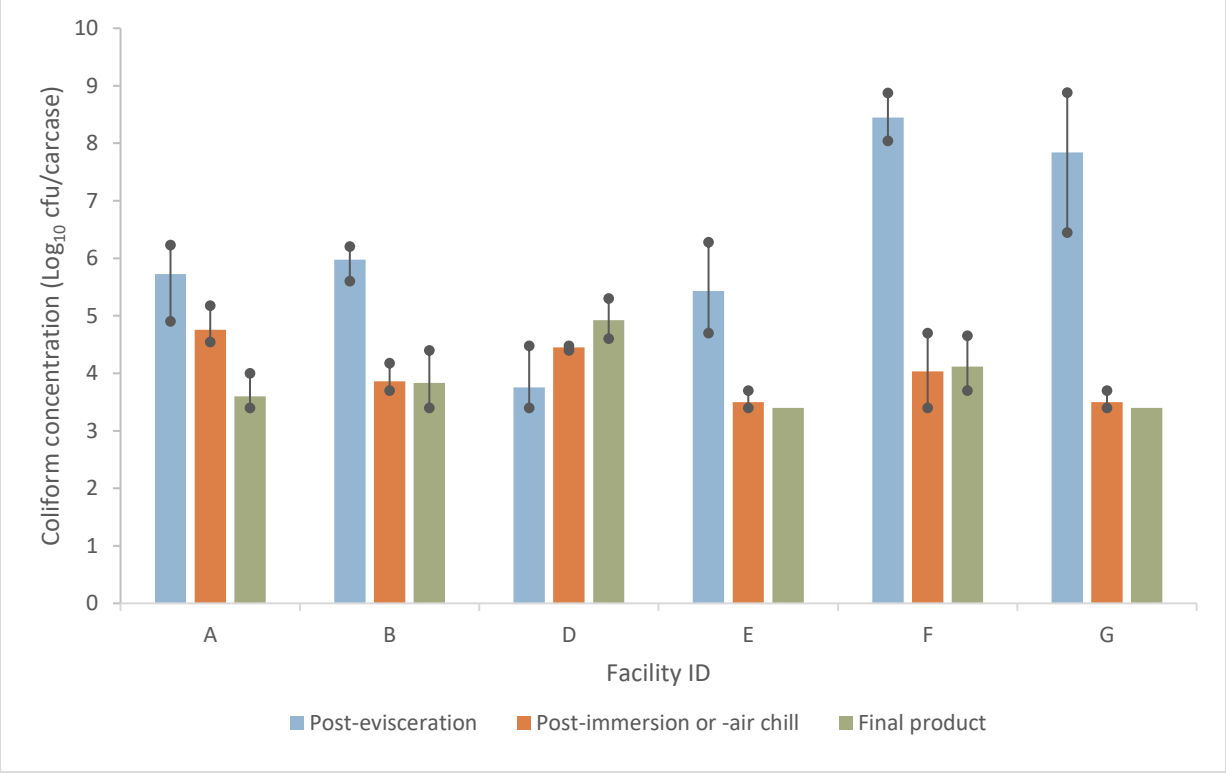

Figure 7: Distribution of coliform concentrations (log_{10} CFU/carcase) sampled on carcases at three points through-chain for all facilities. Coloured bars indicate geometric mean coliform concentration for the sampling site; range bars indicate maximal and minimal detected counts.

Standard Plate Count

Final product Standard Plate Count (SPC) results for all facilities were classed as 'excellent' (table 6; figure 8).

Samples from facilities E and F demonstrated an increase in SPC between post-chilling and final product points. Final product results from facility E were particularly variable. These results will provide an avenue for exploring the effectiveness of good hygienic practices (GHPs) between these two points for both facilities.

No increases in SPC were observed between post-chilling and final product points at facilities A, B, D or G, suggesting that GHPs remain effective in these facilities.

Similar to testing for *E. coli* and coliforms, testing for SPC at the end of processing does not necessarily provide a good indicator of the likelihood of poultry becoming contaminated with *Campylobacter* or *Salmonella* (FSANZ 2010; Lindblad *et al.* 2006).

The highest Standard Plate Count on final product was 6.74 log10 CFU/carcase (facility E).

Table 6: Performance categories for Standard Plate Count (SPC) on chicken meat (based on criteria adapted from Sumner *et al.* 2004; FSANZ 2010)

Category descriptor	SPC (log_{10} CFU/carcase)
Excellent	7
Good	7 - 8
Acceptable	8 - 9
Marginal	9 - 9.5
Poor	> 9.5

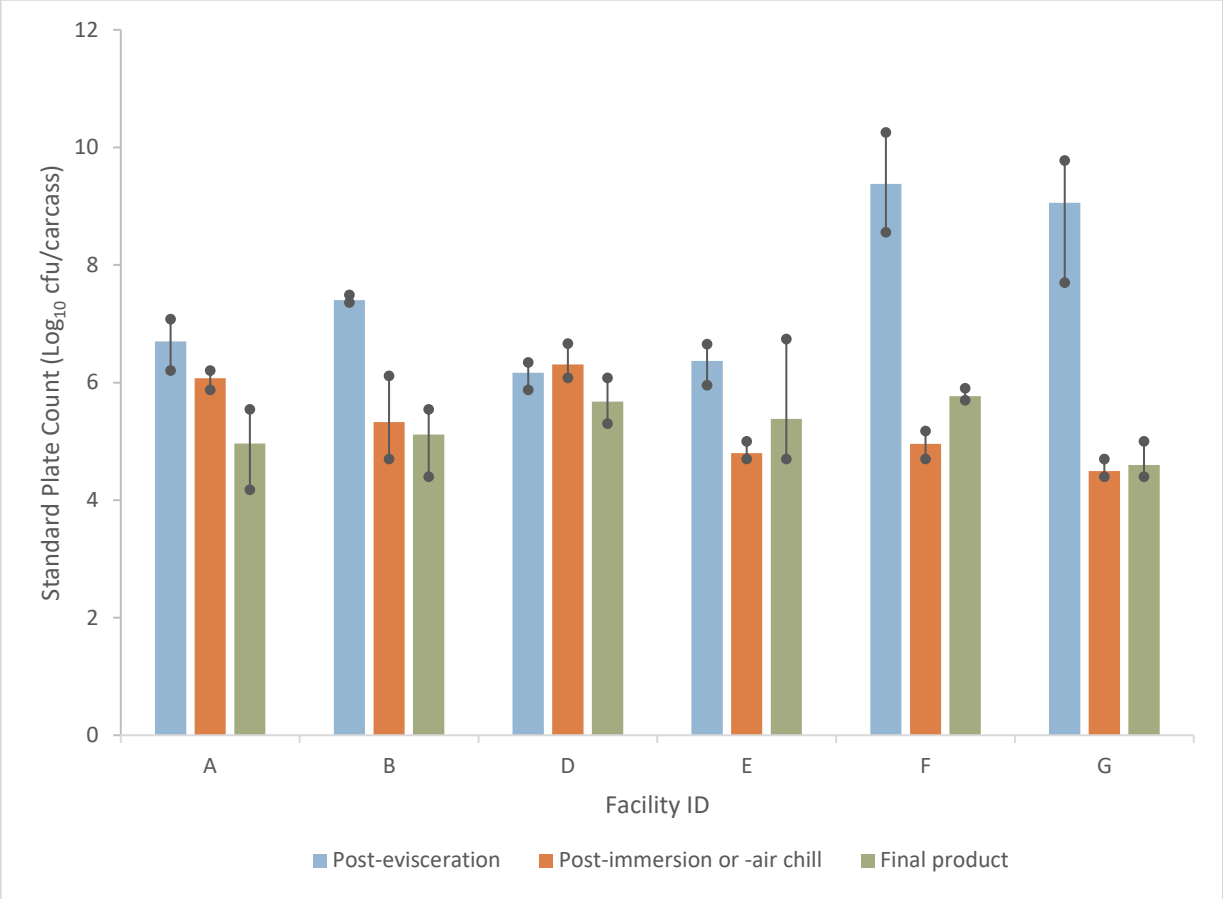

Figure 8: Distribution of SPC (log_{10} CFU/carcase) sampled on carcases at three points through-chain for all facilities. Coloured bars indicate geometric mean SPC concentration for the sampling site; range bars indicate maximal and minimal detected counts.

Conclusions

Presence and control of *Campylobacter* and *Salmonella* in the poultry meat supply chain requires a systematic, through-chain approach to minimise the transmission of these pathogens via food. The work completed in this study provides contemporary insights on the efficacy of food safety controls implemented by Queensland poultry processors. This survey was designed to capture business processing parameters and carcase microbiological profiles at specific points through the production chain to determine the efficacy of certain processes and interventions designed to control or reduce microbiological loads. Conclusions drawn from the survey data further inform the ongoing regulatory discussion regarding poultry meat food safety and public health outcomes.

Poultry processing facilities are generally able to achieve the immersion washing/chilling targets set out in the baseline model. Further work is required for some facilities to consistently meet the target for feed-withdrawal, however. Other site-specific improvements, including prevention of unacceptable carcases entering the immersion wash, are expected to yield improved microbiological results.

Most facilities adequately reduced levels of *E. coli* and coliforms to below 'acceptable' levels, and in many cases, to levels that could be classified as 'excellent'. Good hygienic practices appear adequate in the majority of facilities, with most samples returning 'excellent' or 'good' results for SPC on final product. Data obtained from the present survey provides an avenue for exploring system improvements in the two facilities that experienced an increase in SPC between post-chilling and final product points.

Salmonella is generally well managed through-chain, with most facilities achieving the industry target for final product. Higher and variable counts associated with post-evisceration samples from one facility may justify heightened interventions in the rearing environment, lessening the reliance on critical control points through the processing chain. Closer assessment of the number of unacceptable carcasses identified at washing also warrants further investigation to elucidate the primary driver of this variability for that facility. Data extracted from CIMS suggests that the results obtained in the present survey are reflective of those obtained through internal monitoring programs.

In 2012, nil poultry processing facilities achieved a geometric mean *Campylobacter* concentration of ≤ 6,000 CFU/carcase for final product. In 2019, four out of the six facilities surveyed were able to achieve geometric mean concentrations of *Campylobacter* below the industry-agreed target (≤ 6,000 CFU/carcase). Only two facilities were able to consistently produce final product carcases with concentrations below the industry target, however. The

facilities that were not able to achieve the target consistently also tended to demonstrate greater variability in final product *Campylobacter* concentrations.

Compared to the 2012 Safe Food survey, poultry processing facilities in 2019 demonstrated substantially higher *Campylobacter* concentrations on carcases post-evisceration. Despite this, and a relative increase in production throughput volumes, facilities in 2019 also tended to achieve lower *Campylobacter* concentrations post-chilling and on final product. It is hypothesised that this is, in part, due to the success of baseline model framework and achievement of best practice washing and chilling targets. It's possible that the relatively higher *Campylobacter* concentrations observed post-evisceration are due to a combination of microbial populations of birds and significant increases in product throughput volumes. Whilst the improvement in final product results since 2012 demonstrates the advances industry has made, attention to reducing the initial loads of *Campylobacter* would alleviate the pressure placed on subsequent processing interventions, thus driving further improvement.

It was not possible to tease out the effect of line speeds on microbiological results in the present survey, however this important factor should continue to be considered during ongoing reviews of food safety system performance. The survey data also revealed interesting patterns for some facilities that will provide Safe Food and industry with opportunities for exploration and improvement (e.g. configuration and management of processing equipment).

Campylobacter data submitted to Safe Food via CIMS were generally reflective of that obtained via the present survey. Variation between the two data sets may be due to differences in sampling methodologies and facility sampling rates.

Overall, the study was able to determine the microbiological profiles of poultry carcases at specific points through processing in six Queensland facilities. This study has also demonstrated the continued effectiveness of the baseline model in controlling microbiological hazards associated with poultry meat. This effectiveness, however, relies on continued implementation of the model framework, producing stable food safety systems that yield consistent results. The findings from this survey, in combination with a regulatory assessment were able to assist industry to critically review areas of microbiological control and food safety importance within production facilities. This work also contributes data from the state of Queensland towards the monitoring and surveillance component of Australia's Foodborne Illness Reduction Strategy 2018–2021+.

Industry has made substantial progress to improve control of food safety systems and achievement of baseline model targets. This is evidenced by the significant reduction in *Salmonellosis* notifications in recent times, supported by survey and self-reported data.

Despite these improvements, this survey confirms the presence of *Campylobacter* in concentrations above the industry-agreed targets for some facilities. This demonstrates the need for enhanced monitoring and verification of control points through-processing. Variation in bird sizes within flocks could contribute to variation in product microbiological results given that some mechanised equipment is optimally adjusted for a specific bird size. Inconsistency in product results at some facilities post-wash may warrant further investigation into the influence of line speed and carcase wash contact durations. Product results may be improved consistence in achieving the target for feed withdrawal (8 to 14 hours) and prevention of unacceptable carcases entering the wash. Further investigation should also be conducted into the effectiveness of on-farm measures for controlling *Campylobacter* populations.

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