

Survey of Product Contamination with *Campylobacter* at Retail

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Scientific Interpretive Summary (SIS)

This Scientific Interpretive Summary is prepared by New Zealand Food Safety (NZFS) risk assessors to provide context to the following report for MPI risk managers and external readers. This summary presents an interpretation of the surveillance results only and does not constitute a formal risk assessment.

407173 Survey of Product Contamination with *Campylobacter* at Retail

A survey was commissioned by NZFS to assess the prevalence and concentration of *Campylobacter*, and to identify *Campylobacter* species, in chilled poultry products and associated packaging available at retail in New Zealand. This study was conducted by the Cawthron Institute, with analytical support from Massey University, and the New Zealand Institute for Public Health and Forensic Science (PHF Science), formally known as ESR.

A total of 702 samples were collected from supermarkets in Auckland, Wellington, and Christchurch between January and April 2024. Samples were tested using a modified version of the *Campylobacter* testing method outlined in the National Microbiological Database (NMD) programme. This modification incorporated a centrifugation step to improve the detection limit. NMD refers to MPI's mandatory microbiological monitoring programme, which requires routine sampling and testing of poultry products for *Campylobacter* and *Salmonella*.

Campylobacter spp. was detected in 66.4% of chilled poultry products sampled at retail, with prevalence varying by product type. Offal products showed the highest prevalence and were more frequently associated with higher contamination levels. Skin-off chicken breasts and whole chickens exhibited moderate prevalence, with contamination predominantly occurring at lower levels, although a small proportion of whole-chicken samples contained higher concentrations.

Contamination of external packaging surfaces associated with skin-off chicken products was infrequent, occurring in 1.2% of samples.

Across all products, *Campylobacter jejuni* was the predominant species identified. *Campylobacter coli* was detected less frequently overall, with some regional variation observed in species distribution.

Due to methodological differences (sample types, sample size, detection limits and identification methods) a direct comparison with a similar survey conducted between [September 2010 to August 2011](#) was not intended; however, to the extent possible, observed trends were described. A reduction was observed in the level of *C. jejuni* on whole chicken and chicken breast (skin-off) samples exceeding 200 colony forming units (CFU)/carcass and 50 CFU/portion, respectively. A reduction in samples exceeding high count values of 6000 CFU/carcass and 1000 CFU/portion was also observed, when compared to the 2011 survey.

The current survey found a markedly lower prevalence (1.2%) of *Campylobacter* contamination on external packaging compared to a previously reported prevalence of 24% in 2011 on the same product type but varying sample size. All isolates detected on the external packaging were identified as *C. jejuni*.

The results of this study indicate differences in contamination level across products and regional variation in both prevalence and *Campylobacter* species distribution. While *Campylobacter* was detected in chilled poultry products at retail, most contamination occurs at low levels, with high-level contamination reported less frequently than in earlier surveys. The data generated from this study will contribute to future quantitative risk assessments and provide evidence to support relevant risk management actions and future food safety campaigns. They also offer critical insights for evaluating the feasibility, requirement and impact of implementing a new analytical method to lower the detection limit, thereby enhancing the sensitivity of surveillance.

Survey of Product Contamination with *Campylobacter* at Retail

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SURVEY OF PRODUCT CONTAMINATION WITH *CAMPYLOBACTER* AT RETAIL

EXECUTIVE SUMMARY

Campylobacteriosis, primarily caused by *Campylobacter jejuni* and *Campylobacter coli*, is a significant public health concern in New Zealand, accounting for a large portion of reported gastrointestinal diseases. Current monitoring programs via the National Microbiological Database (NMD) focus on determining and recording *Campylobacter* numbers on poultry carcasses at the end of primary processing. However, recent data on *Campylobacter* spp. prevalence and numbers in retail poultry products are missing. This project, funded by the Ministry for Primary Industries (MPI) and conducted by the Cawthron Institute with assistance from Massey University and The Institute of Environmental Science and Research (ESR), aims to provide current data on prevalence of *Campylobacter* spp. and numbers reported as Colony Forming Units (CFU)/portion found on chilled retail poultry products and their external packaging.

Objectives

The study aimed to collect and collate data on the prevalence (% positive), numbers (CFU/portion), and distribution of different species of *Campylobacter* spp. in chilled poultry products sold at retail in Auckland, Wellington, and Christchurch. These sites were selected to ensure the survey covered poultry products produced at different primary processing sites around New Zealand. Additionally, it aimed to investigate the prevalence of *Campylobacter* contamination on the external surfaces of chicken breast packaging.

To achieve these objectives, the survey detected and quantified *Campylobacter* spp. on chilled poultry products and identified individual *Campylobacter* species using matrix-assisted laser desorption/ionisation time-of-flight mass spectrometry (MALDI-ToF MS). The compiled data was analysed using basic statistical methods and is presented here in this final report.

Methods

A total of 702 samples (including whole chickens, skin-off chicken breasts, offal items, and swabs from the external surfaces of the packs containing skin-off chicken breast) were collected by the NZFS Food Compliance team, following standardised procedures provided by Cawthron Laboratories, from major supermarket suppliers in Auckland, Wellington, and Christchurch during the summer and early autumn of 2024 (January–April). Samples from whole chickens were included in the study, irrespective of whether they were seasoned, marinated, or stuffed. A small number of samples of skin-on chicken breasts and chicken thighs were collected and included in the analysis of skin-off chicken breast samples. All samples were packed into polystyrene boxes containing ice to maintain sample integrity and were transported to Cawthron Laboratories within

30 hours of collection. On arrival the temperature was checked, and all samples were within the required range of 0–10°C.

Swabs from the external surfaces of packaging were tested for *Campylobacter* using an enrichment method to yield a detect/non-detect result (D/ND). All other samples were enumerated for *Campylobacter* using a modified National Microbiological Database (NMD) method. The incorporation of a centrifugation step gave an approximately 10-fold lower detection limit (DL) for *Campylobacter* than the NMD method.

Results

Campylobacter prevalence (%), numbers (CFU/portion) and species varied by product type and location. Overall, 66.4% of poultry products at retail (300 positive, n=452) were found to be contaminated with *Campylobacter*. The highest prevalence of *Campylobacter* contamination was found in offal items (87.7% total *Campylobacter*, n=81), followed by skin-off chicken breasts (64.3%, n=249).

Offal items had the highest numbers of CFU, with 39.5% showing ≥ 1000 CFU/portion (32 positive, n=81), while most of the positive skin-off chicken breasts fell within the low 5–49 CFU/portion range (44.6%, 111 positive, n=249). The CFU counts for positive whole chicken carcass samples were equally distributed in the ranges of 20–199 and 200–5999 CFU/portion, with each range accounting for 27.0% (n=33) of the total (n=122). Additionally, three whole chicken samples (2.5%) contained ≥ 6000 CFU/portion. External packaging (n=250) contamination was low at 1.2% (n=3).

Poultry products obtained from stores in Auckland and Wellington had similar prevalence (72.4%, n=144 and 72.1%, n=136, respectively), while poultry products bought in Christchurch had a lower prevalence of *Campylobacter* spp. (57.0%, n=172). Most chicken breast and offal samples obtained from Auckland and Wellington that were positive for *Campylobacter* ranged between 5–49 CFU/portion (38.2% and 39.8%, respectively, n=330). However, Wellington and Auckland also had a higher proportion of samples with ≥ 1000 CFU/portion (15.3% and 11.8%, respectively) compared to Christchurch (4.9%). Most whole chicken samples obtained from Wellington and positive for *Campylobacter* fell within the 200–5999 CFU/portion range (36.8%, 14 positive, n=38).

C. jejuni and *C. coli* were the only *Campylobacter* species identified on retail poultry products analysed in this study, as the confirmation method used (MALDI–ToF MS) was only able to identify the species of the single isolate tested from each sample. Other species may have been present but were not identified. *C. jejuni* was the predominant species across all locations (82.6%, 237 positive, n=300) and product types, ranging from 81.2% identified as *C. jejuni* in offal items (56 isolates, n=71) to 83.7% identified as *C. jejuni* in skin-off chicken breast samples (128 isolates, n=160). *C. jejuni* was the only species detected on the external surface of packaging. There were regional variations in the prevalence of *C. coli*, with a higher prevalence in poultry products obtained from Wellington (25.5%, 25 positive, n=98), than Auckland (15.2%, 16 positive, n=105) or Christchurch (8.2%, 8 positive, n=98). However, further investigation of all data is needed to allow for meaningful interpretation, as differences in sample size and product type may lead to biases.

Conclusions

This survey has generated valuable data for *Campylobacter* spp. prevalence, counts as CFU/portion as summarised in different ranges from 5 to ≥ 1000 CFU/portion and 20 to ≥ 6000 CFU/portion, and species distribution on poultry products and packaging sold at retail in Auckland, Wellington, and Christchurch.

PROJECT PURPOSE

Campylobacteriosis, primarily caused by *Campylobacter jejuni* and *Campylobacter coli*, poses a significant public health concern in New Zealand, contributing substantially to reported gastrointestinal diseases and hospital admissions.^{1,2} Poultry products are considered to be the primary source of *Campylobacter* infections, underscoring the need for ongoing efforts to enhance hygiene standards and control measures across the poultry food supply chain.^{3–6} This project is part of a broader effort of NZFS's strategy to address the significant health burden posed by campylobacteriosis in New Zealand and reduce the incidence of foodborne domestically acquired human campylobacteriosis by 20% by the end of 2024.⁷

Current monitoring programmes via the National Microbiological Database (NMD) focus on determining and recording *Campylobacter* numbers on poultry carcasses at the end of primary processing.⁸ Recent data on *Campylobacter* prevalence and numbers in retail poultry products are lacking. Previous studies indicate that contamination levels at secondary processing stages are higher than those recorded at the end of primary processing.⁹ Moreover, changes in packaging methods over time may have influenced contamination rates on package exteriors. This project, funded by the Ministry for Primary Industries (MPI) and conducted by the Cawthron Institute with assistance from Massey University and The Institute of Environmental Science and Research (ESR), aims to provide current data on *Campylobacter* spp. prevalence and numbers as CFU/portion in chilled retail poultry products. This survey utilises the method described in Kingsbury et al. 2023,⁹ including a centrifugation step for 30 minutes at 4430 x g, to detect *Campylobacter* at lower levels than previously possible. MALDI–ToF–MS was conducted at Massey University (MU), as described in previous publications,^{10,11} to identify different *Campylobacter* species isolated from the poultry products.

The study sought to assess the prevalence and concentration of *Campylobacter* on chilled poultry meat sold at retail, including chicken breasts, whole chicken carcasses, and offal items. In addition, the external surface of packed poultry meat was tested for the presence of *Campylobacter* to assess the potential risk to consumers of cross-contamination via packaging. The survey collected products from a range of supermarket chains and brands in three cities (Auckland, Wellington, and Christchurch), to ensure the survey covered poultry products produced at different primary processing sites around New Zealand. The survey was conducted during summer and early autumn (from January to April 2024), which has previously been determined as the time period when there is the highest seasonal prevalence of *Campylobacter* in poultry.^{3,4}

Objectives

The overall objectives of the study are to:

1. Assess the prevalence (%) and number (CFU/portion) of different *Campylobacter* species (including, but not limited to *C. lari*, *C. jejuni*, and *C. coli*) in a wide range of poultry products obtained from a range of supermarket chains and brands in three cities (Auckland, Wellington, and Christchurch), to ensure the study included a variety of poultry products from different primary processing sites across New Zealand.
2. Determine the prevalence (%) of *Campylobacter* contamination on the external surface of packs containing chicken breast.

To achieve these objectives, this survey specifically aims to:

1. Detect and quantify *Campylobacter* spp. on chilled poultry products by Cawthron Laboratories.
2. Identify *Campylobacter* species by MALDI–ToF MS, conducted at MU.
3. Collect and compile raw data to provide these in an agreed format to the Ministry for Primary Industries (MPI) for further analysis.
4. Present compiled data using basic statistical methods in a final report.

There is the potential to compare the results from the current study with earlier studies,^{3,4} with caveats that the sampling sets, methods, and sampling periods differ.

METHODS

Sampling Procedure

Sampling was conducted by the NZFS Food Compliance team following procedures provided by Cawthron Laboratories (Appendix 1). The sampling strategy targeted supermarket retail outlets, which are the major supplier of poultry products in three New Zealand/Aotearoa cities, namely Auckland, Wellington, and Christchurch. Retail outlets included two supermarket chains and 15 different brands of poultry products. A total of 702 samples were collected (see Sample Collection and Transport section below for details), including whole chickens, skin-off chicken breast products, poultry offal items (including livers, necks, giblets, frames, hearts, and gizzards), and swabs of the external packaging of skin-off chicken breast products (Table 1). All samples and associated metadata received a unique identifier code (Appendix 2). The raw data were captured in an Excel workbook which was shared with MPI.

Table 1. Samples collected and tested in this study.

Product Type	Sample number
Whole chickens*	122
Skin-off chicken breast†	249
External surface of skin-off chicken breast packaging	250
Offal items	81
Total, excluding external surface of packaging	452
Total	702

*Including 19 samples of various prepared and marinated whole chickens.

†Including one thigh fillet and four skin-on chicken breast samples.

Sample Collection and Transport

Raw, chilled samples weighing at least 200 g were collected from retail outlets following the agreed sampling plan and procedures (Appendix 1). Sampling locations were selected by NZFS and an additional round of sampling was added for Christchurch in April 2024 to ensure equal representation and consistency in data collection across the targeted cities and brands. To maintain sample integrity, samples were packed into polystyrene boxes containing ice and transported to Cawthron Laboratories within 30 hours of collection. Upon arrival, the temperature of all samples was checked. All samples were received within the acceptable range of between 0–10°C and arrived in less than 30 hours from purchase. Samples were stored within the polystyrene boxes with ice pads until tested (within 4 hours).

Microbiological Testing

All samples were processed and tested at Cawthron Laboratories in Nelson according to the procedures outlined in Cawthron QSM 5 method 10.071B (Appendix Appendix 3). The RCF method (adapted NMD), was used to enumerate *Campylobacter* in the poultry samples.⁹ Briefly, whole chickens were placed into sterile bags and rinsed with 400 mL Buffered Peptone Water for 2 minutes. From this 50 mL of rinsate was removed and centrifuged (30 minutes at 4430 x g) to pellet debris, then 45 mL of the supernatant was removed. The pellet was resuspended in the remaining 5 mL of rinsate. Then aliquots were spread-plated onto mCCDA plates (333 µL per plate, six plates per sample) and 0.1 mL of a 10-fold dilution was plated in duplicate onto mCCDA plates. All plates were incubated at 42°C ±1°C for 48 hours under microaerobic conditions using MGC Pack MicroAero (atmospheric conditions containing between 6 – 12% O₂ and 5 – 8% CO₂ concentration; Mitsubishi Gas Chemical AnaeroPack™ MicroAero). Skin-off chicken breasts and poultry offal were rinsed with 100 mL Buffered Peptone Water and subsequently processed as above.

Swabbing of external packaging was performed by samplers using a pre-moistened swab according to the protocol and video provided by Cawthron lab (Appendix 1). Swabs were individually placed into a sterile bag for sending to the laboratory. A 50 mL aliquot of Bolton Broth was added to the swab, massaged, and broth and swab incubated for 4 hours at 37°C ±0.5°C, followed by a further 44 hours at 42°C ±1°C under microaerobic conditions. Then 0.1 mL from each swab enrichment broth was streaked onto mCCDA and incubated at 42°C ±1°C for a further 48 hours microaerobically. (AnaeroPack™ – MicroAero).

Campylobacter colonies on mCCDA Agar are round to irregular grey colonies with smooth edges. Up to five typical colonies per sample were streaked onto Blood Agar plates to ensure a pure culture for confirmations. Plates were incubated microaerobically at 42°C ± 1.0 for 48 hours ±2 hours to obtain single colonies. Confirmation procedures performed by Cawthron Laboratories were detection of catalase activity and oxidase activity, and Gram stain.

The CFU per carcass or portion result is based on dilution factors and colony counts. The RCF method has a theoretical lower detection limit (DL) for *Campylobacter* of <20 CFU/portion for whole chicken carcasses, and <5 CFU/portion for breast/offal. The lower detection limits are calculated based on the volume used for rinsing the samples, 400 mL for whole chicken and 100 mL for breast/offal, together with the amount of rinsate retained (see Appendix 3, 5.6 Result Calculations for further information). The swab results from external packaging were expressed as detected/non-detected (D/ND). A representative isolate from all positive poultry samples, and swabs from external surfaces, was sent to Massey University for phenotypic identification of *Campylobacter* species by MALDI-ToF MS as described in Nisa et al. 2019 and Bloomfield et al. 2020.^{10,11} The representative positive isolate sent for MALDI-ToF MS gave *Campylobacter* positive results using confirmatory testing (see Appendix 3, Section 5.5.3). The same isolate sent for MALDI-ToF analysis was stored on cryo-beads at -80°C for further testing, if required.

Data Analysis and Presentation

The data were analysed and presented similarly to Moorehead et al. 2015.⁴ Results were analysed across different poultry product types and geographical locations to gain insights into *Campylobacter* distribution and overall prevalence. Prevalence was calculated by dividing the number of positive samples (>DL) by the total number of samples tested and represented as a percentage. Confidence intervals for these prevalence estimates were calculated using the binomial proportion confidence interval method. This provides a 95% confidence interval to indicate the range likely to contain the true prevalence percentage, reflecting the precision of the estimates.¹²

Quantitative data were categorised into different ranges and presented in CFU/portion based on enumeration. Due to differing detection limits, distinct ranges were used for chicken breast and offal items (DL < 5 CFU/portion) and whole chickens (DL < 20 CFU/portion). The ranges were:

- Chicken breast and offal items: <DL (5), 5–49, 50–999, ≥1000 CFU/portion
- Whole chickens: <DL (20), 20–199, 200–5999, ≥6000 CFU/portion

The 5–49 and 20–199 categories capture *Campylobacter* counts that would have been missed in previous studies, such as in Moorehead et al. 2015,⁴ where the detection limits were <50 CFU/portion and <200 CFU/portion, respectively. The ranges of ≥1000 and ≥6000 CFU/portion were selected to highlight high-count samples, including (in the case of whole chickens) those that exceed the enumeration target set in the NZFS National Microbiological Database Programme. Descriptive statistics, including mean, standard deviation, and standard error, were used to summarise the data's central tendency and variability. The margin of error was calculated to indicate the range within which the true prevalence rate is expected to lie. Data are presented as prevalence percentages and bar graphs of quantitative data, with tables detailing prevalence with confidence intervals. Incomplete data from a few samples were excluded from calculations and graphs.

RESULTS

Prevalence of *Campylobacter* in Retail Poultry Samples

A total of 702 poultry samples (meat and offal items: n=452, and outside packaging: n=250) were collected and tested from various retail outlets and 15 different brands from Auckland (n=144), Wellington (n=136), and Christchurch (n=172), during the summer months of January to April 2024.

Four sampling rounds were conducted for Auckland (on the 24/01/2024, 13/02/2024, 05/03/2024, and 19/03/2024), Wellington (on the 30/01/2024, 20/02/2024, 12/03/2024, and 02/04/2024), and Christchurch (on the 07/02/2024, 27/02/2024, 18/03/2024, and 25/03/2024), collecting up to 60 samples per round, including swabs of the external packaging. An additional fifth sampling round was conducted for Christchurch on the 08/04/2024.

Campylobacter species were analysed for 303 isolates from positive samples (chicken breast: n=160, offal: n=71, whole chicken: n=69, external packaging: n=3) by their MALDI-ToF spectral pattern (Table 4, Figure 4). Of these, 290 *Campylobacter* isolates were identified either as *C. jejuni* (n=240, including 3 positives from swabs of the external packaging) or as *C. coli* (n=50). However, 13 isolates, four from Auckland (AU-WCH-004 and -018, AU-CHBoff-040 and -076), seven from Wellington (WLG-CHBoff-001, -002, -013, -015, and -018, WLG-WCH-003 and -006), and two from Christchurch (CC-OF-05 and -06) were found to be positive for *Campylobacter*, but no species identification was able to be made by MALDI-ToF MS. These 13 isolates were unable to be revived from cryo-bead storage, which meant that species identification was not possible.

Analysis of *Campylobacter* by Product Type

The prevalence of *Campylobacter* contamination varied among different poultry product types, as detailed in Table 2. Prevalence (% positive) and enumeration of *Campylobacter* contamination as CFU/portion across these different product types are shown in Figure 1.

Offal items (n=81) showed the highest prevalence, with 87.7% positive for *Campylobacter*, of which 78.9% were identified as *C. jejuni* (56 isolates, n=71), and 18.3% as *C. coli* (13 isolates, n=71). Offal items also had the highest proportion of samples with ≥ 1000 CFU/portion (39.5%, 32 positives, n=81).

Among skin-off chicken breasts (n=249), 64.3% were positive for *Campylobacter*, with 80.0% positive for *C. jejuni* (128 isolates, n=160) and 15.6% positive for *C. coli* (25 isolates, n=160). Most of the skin-off chicken breast samples showed CFU in the range of 5–49 CFU/portion (44.6%, 111 positives, n=249).

Whole chicken carcasses (n=122) had a *Campylobacter* prevalence of 56.6%, with 76.8% positive for *C. jejuni* (53 isolates, n=69) and 17.4% positive for *C. coli* (12 isolates, n=69). CFU counts for positive whole chicken carcass samples were equally distributed in the ranges of 20–199 and 200–5999 CFU/portion, with each range accounting for 27.0% (33 positives each, n=122). Additionally, three whole chicken samples (2.5%) contained ≥ 6000 CFU/portion.

Swabs of the external surfaces of poultry packaging (n=250) were tested for presence of *Campylobacter* spp. (D/ND method), revealing only three positive samples (1.2%): two from Wellington and one from Auckland. All three positive external packaging samples were identified as *C. jejuni*.

Table 2. Prevalence and 95% confidence intervals of *Campylobacter* in retail poultry samples according to product type.*

Poultry Product Type (no. tested)	No. total <i>Campylobacter</i> (% positive, CI)	No. <i>C. jejuni</i> only† (% positive, CI)	No. <i>C. coli</i> only† (% positive, CI)
Offal items (81)	71 (87.7 , 86.6 – 88.7)	56 (78.9 , 77.9 – 79.9)	13 (18.3 , 17.3 – 19.3)
Skin-off chicken breast (249)‡	160 (64.3 , 59.2 – 69.3)	128 (80.0 , 75.0 – 85.0)	25 (15.6 , 10.6 – 20.6)
Whole chicken (122)§	69 (56.6 , 55.0 – 58.2)	53 (76.8 , 75.2 – 78.4)	12 (17.4 , 15.8 – 19.0)
External packaging (250)	3 (1.2 , 0.9 – 1.5)	3 (100.0 , 99.7 – 100.0)	0 (0.0 , 0.0 – 0.3)
Total, excluding outside packaging (452)	300 (66.4, 62.5 – 70.3)	237 (79.0, 75.1 – 82.9)	50 (16.7, 12.8 – 20.6)

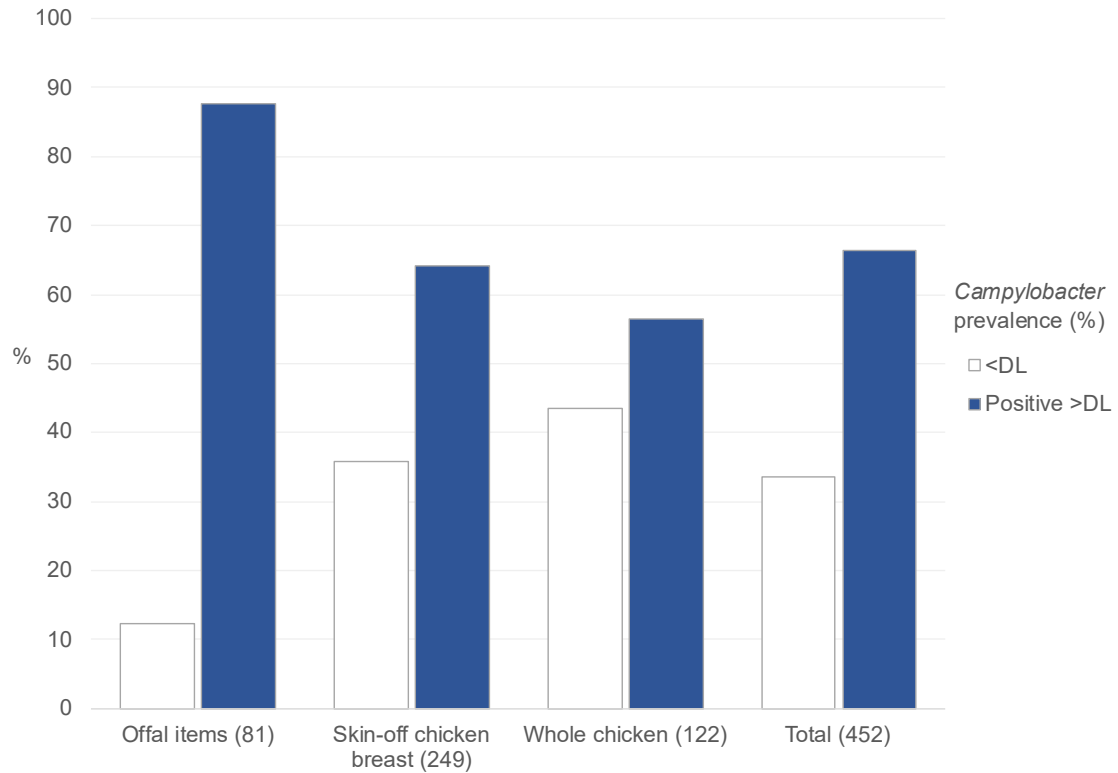
* Excluding samples <DL (DL = 5 CFU/portion for chicken breast and offal items, and 20 CFU/portion for whole chicken).

† Excluding samples without species ID (n=13).

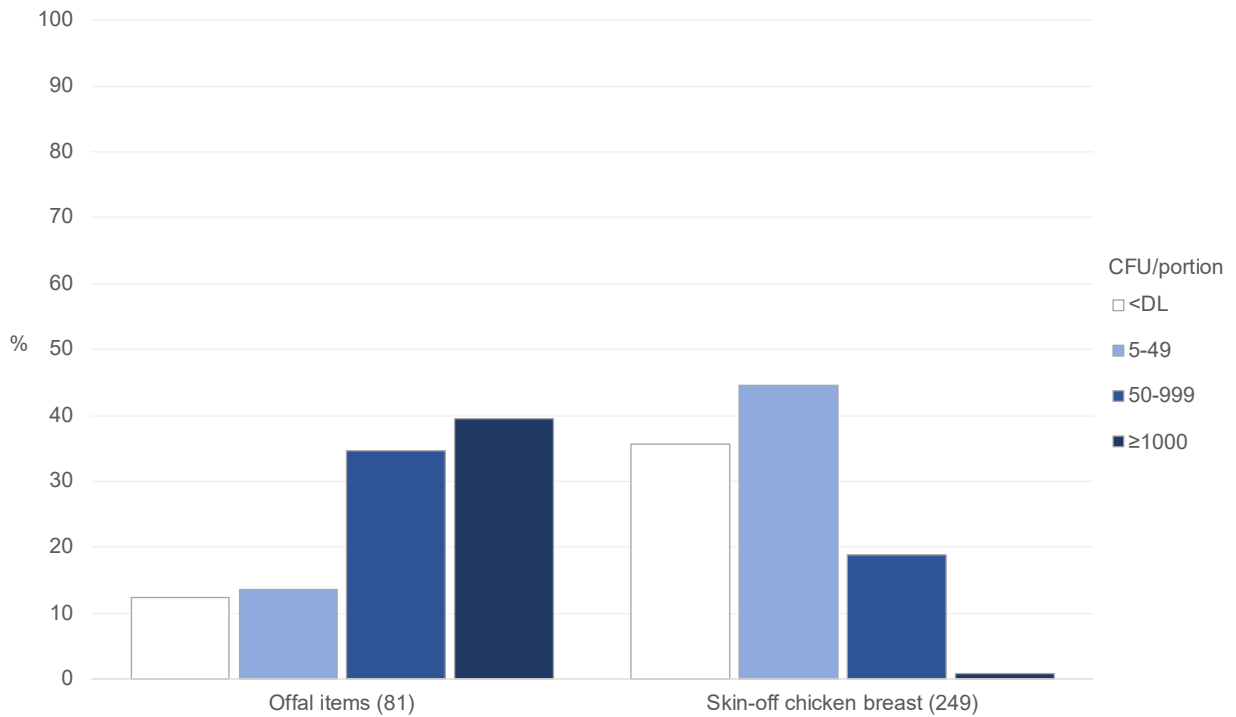
‡ Including thigh fillet and skin-on chicken breast.

§ Including various prepared and marinated whole chickens.

A



B



C

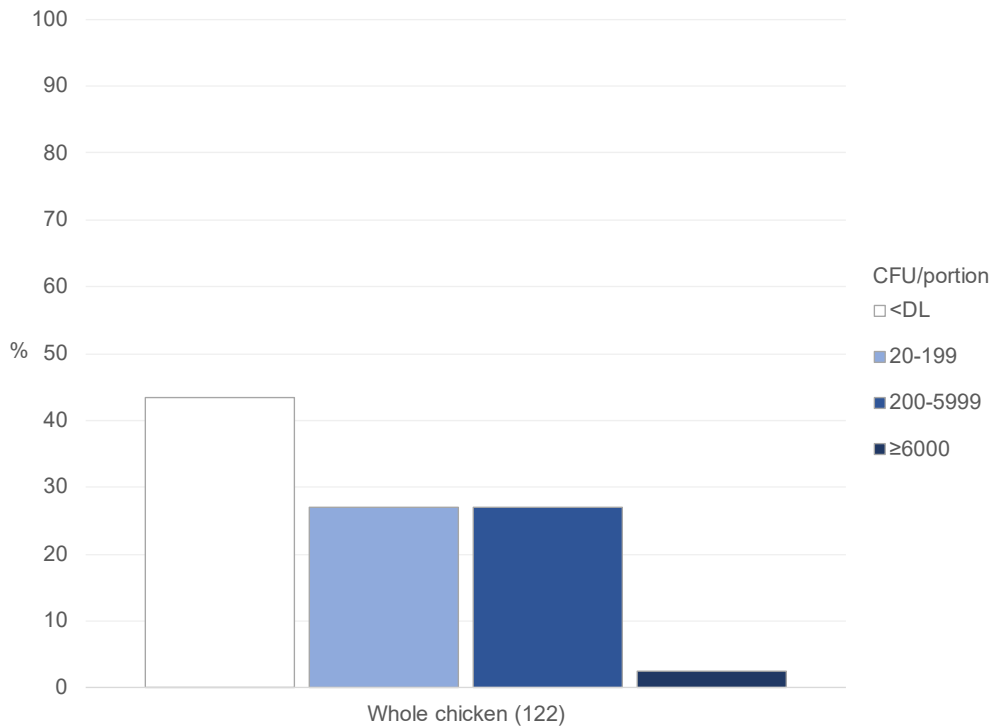


Figure 1. (A) Prevalence (%) of *Campylobacter* spp., **(B)** percentage of *Campylobacter* counts per enumeration category in offal items and chicken breast products (n=330), and **(C)** percentage of *Campylobacter* counts per enumeration category in retail whole chicken products (n=122). Detection limit (DL) set at <5 CFU/portion for chicken breast and offal items, and at <20 CFU/portion for whole chicken carcasses.

Analysis of *Campylobacter* by Location

Geographical analysis revealed variations in *Campylobacter* prevalence and species distribution among poultry products from Auckland, Christchurch, and Wellington, detailed in Tables 3 and 4. Figure 2 and Figure 3 show the prevalence (%) and percentage of positive samples per CFU/portion by location, while Figure 4 depicts identified species (*C. jejuni* or *C. coli*) relative to location.

Regional disparities were evident, with Auckland and Wellington showing higher prevalence of *Campylobacter* contamination in retail poultry products compared to Christchurch. In Auckland 72.2% of samples tested positive for *Campylobacter* (104 positives, n=144), with 80.8% being identified as *C. jejuni* (84 isolates, n=104) and 15.4% as *C. coli* (16 isolates, n=104). Wellington's poultry samples had a 72.1% prevalence (98 positives, n=136), with 66.3% identified as *C. jejuni* (65 isolates, n=98) and 26.5% as *C. coli* (26 isolates, n=98). Poultry samples obtained from Christchurch had a lower prevalence of 57.0% *Campylobacter* contamination (98 positives, n=172), with 89.8% *C. jejuni* (88 isolates, n=98) and 8.2% *C. coli* (8 isolates, n=98).

Overall, *C. jejuni* was the predominant species across all product types and locations, accounting for 79.0% of positive samples (237 positives, n=300). The species of a small proportion of isolates from positive samples (4.3%, 13 samples, n=300) remained unidentified due to isolates not being able to be typed by MALDI–ToF and then not being able to be revived, occurring in Wellington (7.1%, n=7), Auckland (3.8%, n=4), and Christchurch (2.0%, n=2).

In terms of enumeration, chicken breast and offal samples positive for *Campylobacter* spp. obtained from all three cities ranged overall between 5–49 CFU/portion (37%, 122 positives, n=330), 50-999 CFU/portion (22.7%, 75 positives), and ≥ 1000 CFU/portion (10.3%, 34 positives), while whole chicken samples ranged equally between 20-199 and 200-5999 CFU/portion (27.0%, 33 positives each, n=122), and ≥ 6000 CFU/portion (2.5%, 3 positives).

A higher proportion of retail poultry samples with *Campylobacter* counts in the category ≥ 1000 CFU/portion was found in Wellington (15.3%, 15 samples, n=98) and Auckland (11.8%, 13 samples, n=110), while Christchurch had a lower proportion of products with counts ≥ 1000 CFU/portion (4.9%, 6 samples, n=122). All three cities had one whole chicken sample with ≥ 6000 CFU/portion each.

Table 3. Prevalence and 95% confidence intervals of *Campylobacter* in retail poultry samples relative to geographical source.*

Sample Source (no. tested)	No. total <i>Campylobacter</i> (% positive, CI)	No. <i>C. jejuni</i> only† (% positive, CI)	No. <i>C. coli</i> only† (% positive, CI)
Auckland (144)	104 (72.2 , 70.8 – 73.6)	84 (80.8 , 79.4 – 82.2)	16 (15.4 , 14.0 – 16.8)
Wellington (136)	98 (72.1 , 70.9 – 73.3)	65 (66.3 , 65.1 – 67.5)	26 (26.5 , 25.3 – 27.7)
Christchurch (172)	98 (57.0 , 55.7 – 58.3)	88 (89.8 , 88.5 – 91.1)	8 (8.2 , 6.9 – 9.5)
Total (452)	300 (66.4 , 62.5 – 70.3)	237 (79.0 , 75.1 – 82.9)	50 (16.7 , 12.8 – 20.6)

* Excluding samples <DL (DL = 5 CFU/portion for chicken breast and offal items, and 20 CFU/portion for whole chicken).

† Excluding samples without species ID (n=13) and external packaging (n=3).

Table 4. Prevalence and 95% confidence intervals of *Campylobacter* in retail poultry samples relative to the different identified species at each location.*

<i>Campylobacter</i> isolates (no. tested)	No. from Auckland (% positive, CI)	No. from Wellington (% positive, CI)	No. from Christchurch (% positive, CI)
<i>C. jejuni</i> (237)	84 (80.8 , 75.0 – 86.6)	65 (66.3 , 60.5 – 72.1)	88 (89.8 , 84.0 – 95.6)
<i>C. coli</i> (50)	16 (15.4 , 14.4 – 16.4)	26 (26.5 , 25.5 – 27.5)	8 (8.2 , 7.2 – 9.2)
N/A = not identified (13)	4 (3.8 , 3.2 – 4.4)	7 (7.1 , 6.5 – 7.7)	2 (2.0 , 1.4 – 2.6)

* Including samples without species ID (N/A) but excluding external packaging (n=3).

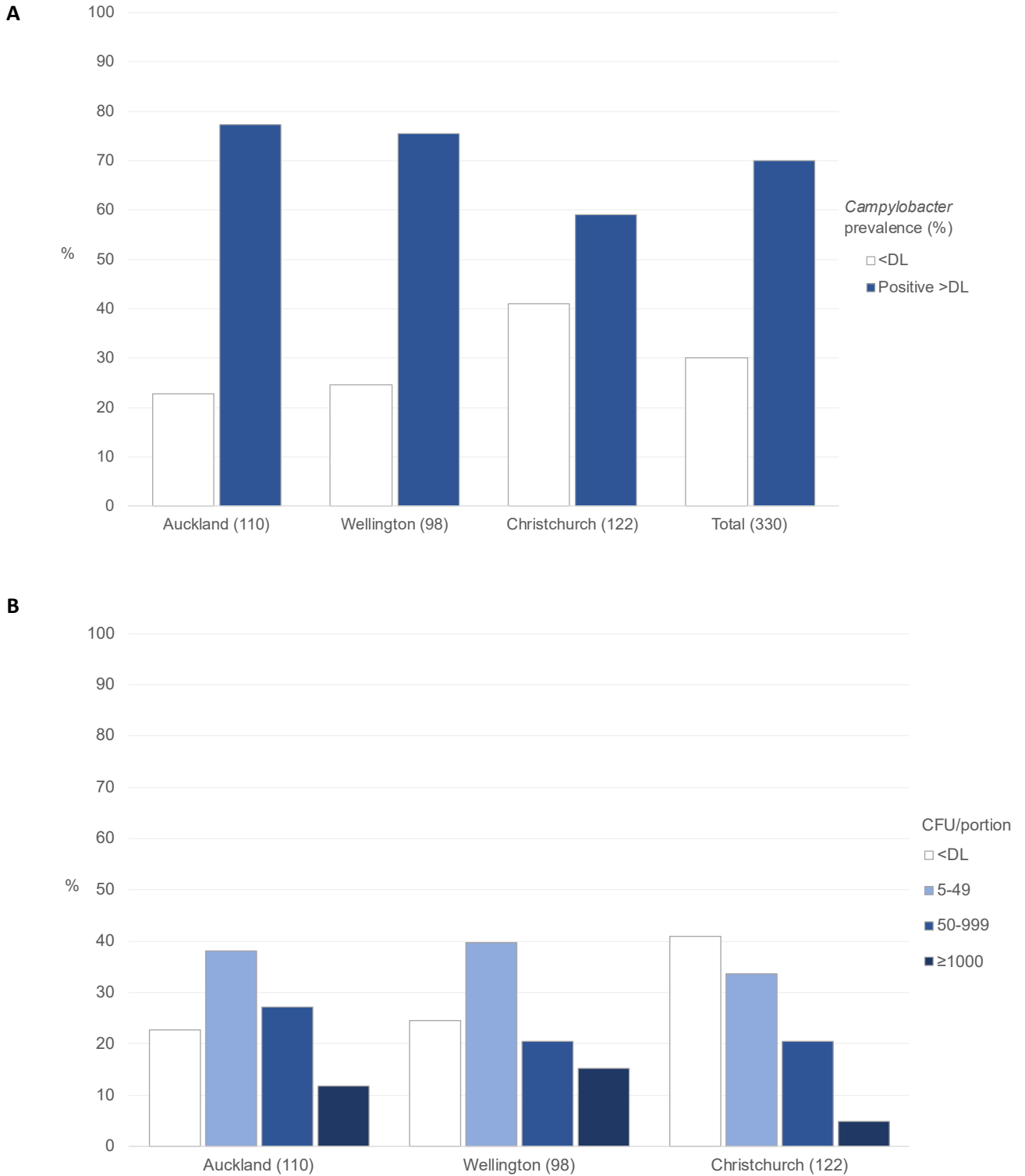


Figure 2. (A) Prevalence (%) of *Campylobacter* spp., and **(B)** percentage of *Campylobacter* counts per enumeration category in chicken breast and offal samples (n=330) collected at different locations in New Zealand. Detection limit (DL) set at <5 CFU/portion for chicken breast and offal items.

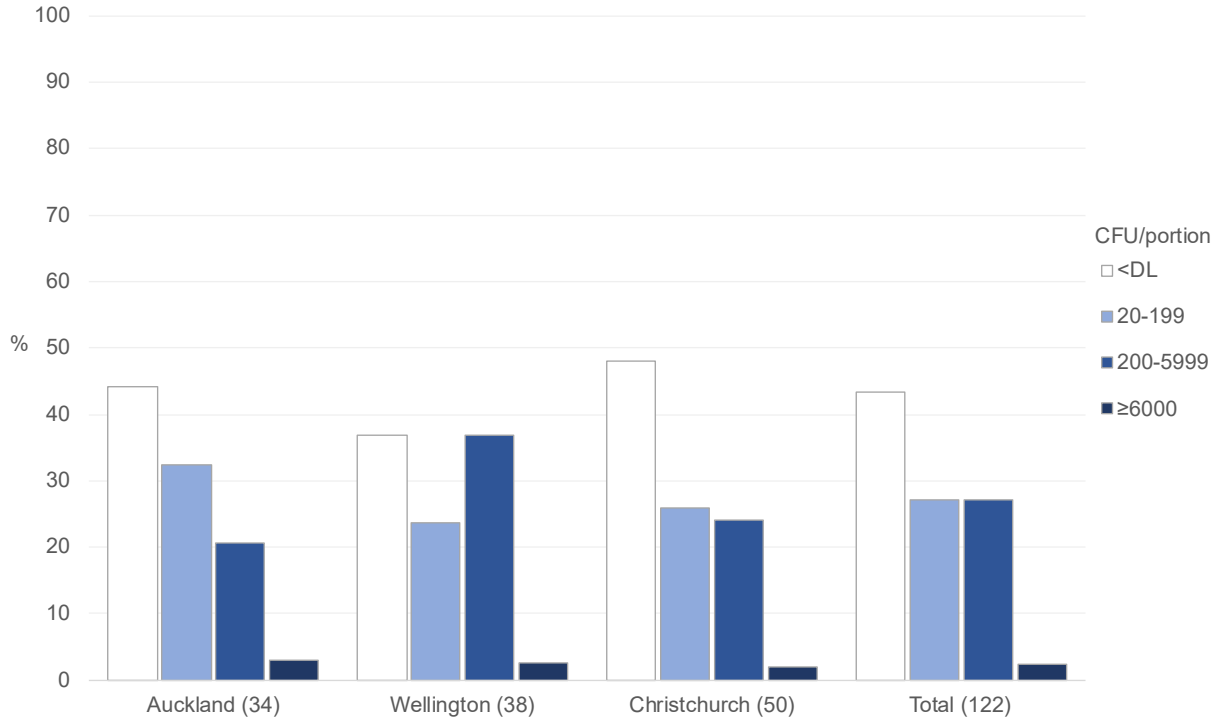


Figure 3. Percentage of *Campylobacter* counts per enumeration category in whole chicken samples (n=122) collected at different locations in New Zealand. Detection limit (DL) set at <20 CFU/portion for whole chicken carcasses.

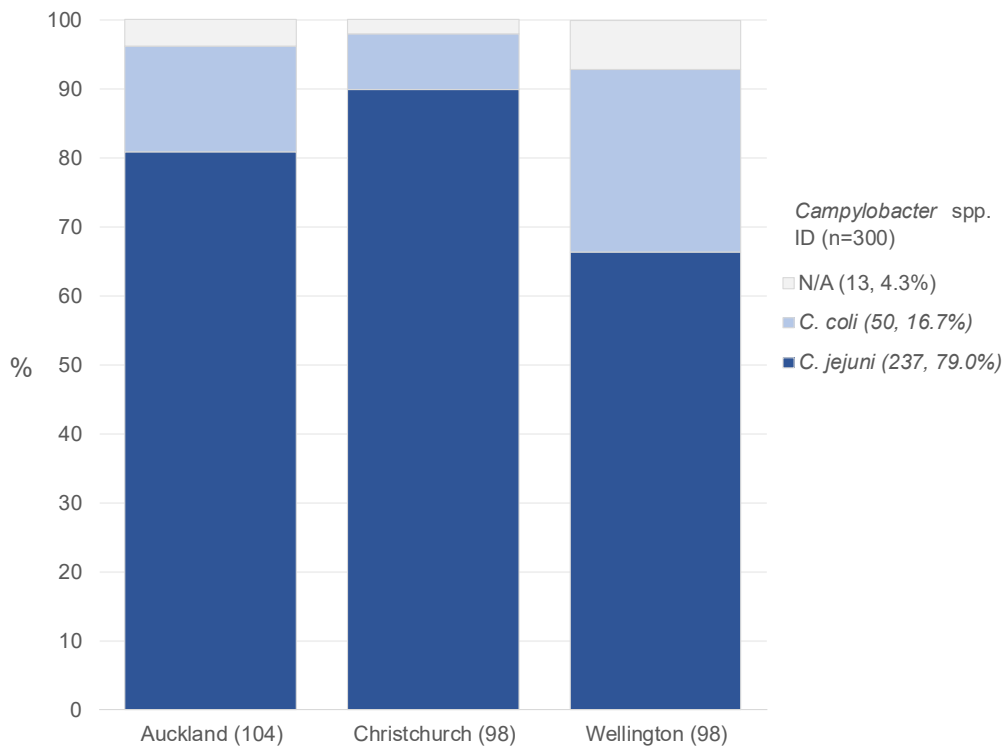


Figure 4. Percentage of the different identified *Campylobacter* spp., *C. jejuni* and *C. coli* (n=300, excluding external packaging), in retail poultry products relative to location.

CONCLUSIONS

This report presents collected and compiled data on *Campylobacter* spp. found on poultry products and their external packaging sold at retail in New Zealand. Descriptive analysis was used to assess the prevalence (%) and numbers (CFU/portion) of *Campylobacter* spp., identifying different species by MALDI–ToF MS. The study covered various chicken products and packaging (n=702) collected from Auckland, Wellington, and Christchurch during the summer and early autumn months of 2024 (January–April).

The prevalence of *Campylobacter* contamination was 66.4% (300 positives, n=452) and varied among different poultry product types, with offal items showing the highest prevalence (87.7%, 71 positives, n=81). Samples from Auckland (72.2%, 104 positives, n=144) and Wellington (72.1%, 98 positives, n=136) had higher *Campylobacter* spp. contamination rates compared to Christchurch (57.0%, 98 positives, n=172). However, this data needs to be investigated further, as differences in sample size, as well as product types, may lead to biases.

Overall, *C. jejuni* was the most prevalent species in retail poultry products (79.0%, 237 isolates, n=300), particularly in Christchurch (89.8%, 88 isolates, n=98), while Wellington had the highest proportion of *C. coli* (26.5%, 26 isolates, n=98).

While an earlier study reported a 24% prevalence of *Campylobacter* contamination on external packaging,¹³ the current survey shows a much lower prevalence of 1.2%. All *Campylobacter* spp. present on the external packaging were identified as *C. jejuni*.

Overall, this study collected and provided valuable data and insights into total *Campylobacter* spp. prevalence, numbers, and the distribution of different *Campylobacter* species on poultry products and packaging at retail.

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APPENDICES

Appendix 1. Sampling plan and sampling instructions provided to MPI by the Cawthron Institute.

	Day of receipt at Lab	Auckland				Wellington				Christchurch				Total Samples Per Day	Product	Swabs
		Enumeration		Detect / Not Detect		Enumeration		Detect / Not Detect		Enumeration		Detect / Not Detect				
		Whole chickens	Skin-off Chicken breast	Offal Items	Outside packaging of skin-off chicken breast	Whole chickens	Skin-off Chicken breast	Offal Items	Outside packaging of skin-off chicken breast	Whole chickens	Skin-off Chicken breast	Offal Items	Outside packaging of skin-off chicken breast			
23/01/2024	Tuesday													0	0	0
	Wednesday	10	20	10	20									60	40	20
	Thursday													0	0	0
30/01/2024	Tuesday													0	0	0
	Wednesday					10	20	10	20					60	40	20
	Thursday													0	0	0
6/02/2024	Tuesday*													0	0	0
	Wednesday													0	0	0
	Thursday									10	20	10	20	60	40	20
13/02/2024	Tuesday													0	0	0
	Wednesday	10	20	10	20									60	40	20
	Thursday													0	0	0
20/02/2024	Tuesday													0	0	0
	Wednesday					10	20	10	20					60	40	20
	Thursday													0	0	0
27/02/2024	Tuesday													0	0	0
	Wednesday									10	20	10	20	60	40	20
	Thursday													0	0	0
5/03/2024	Tuesday													0	0	0
	Wednesday	10	20	10	20									60	40	20
	Thursday													0	0	0
12/03/2024	Tuesday													0	0	0
	Wednesday					10	20	10	20					60	40	20
	Thursday													0	0	0
19/03/2024	Tuesday									10	20	10	20	60	40	20
	Wednesday	10	20	10	20									60	40	20
	Thursday													0	0	0
26/03/2024	Tuesday*									10	20	10	20	60	40	20
	Wednesday													0	0	0
	Thursday													0	0	0
2/04/2024	Tuesday													0	0	0
	Wednesday					10	20	10	20					60	40	20
	Thursday													0	0	0

Sampling plan as agreed upon in the project plan. An additional round of sampling was conducted for Christchurch in April 2024 to ensure good representation of samples across all products and locations.

Instructions for swabbing packaging and product sampling

Equipment required

Supplied by Cawthron

- Sterile gauze swabs moistened with buffering agent containing peptone, thiosulphate and tween 20. (Supplied by Fort Richard Laboratories in sterile containers). There are 10 swabs in each bottle. Store in refrigerator.
- Whirlpak sample bags
- Sterile plastic sheets
- Pre-registered sample labels for each product type, per sampling round.
- Sample submission forms.

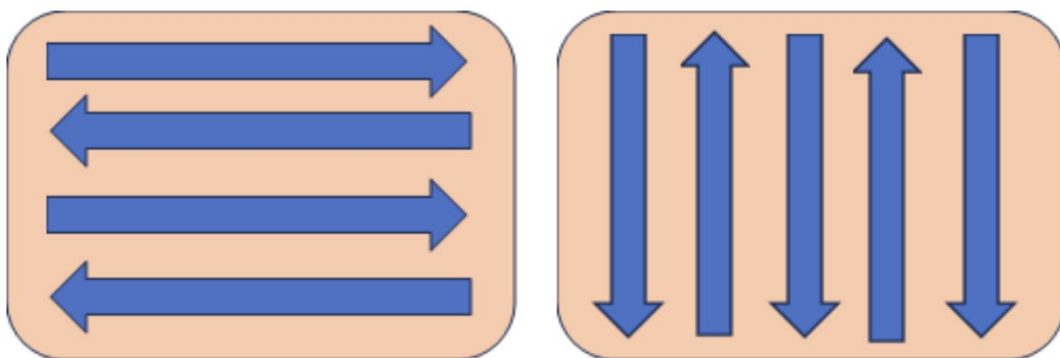
Sourced by MPI

- Disposable gloves
- Permanent Marker Pen
- Designated area allocated for swabbing with sterile plastic sheet on which to place sample.

Procedure

Swabbing of Packaging

1. Label whirlpak bag with pre-registered Cawthron labels .
2. Designated swabbing area is prepared with all equipment required. A sheet of sterile plastic is laid out to place the item to be swabbed onto, ensuring that the plastic is larger than the item to be swabbed.
3. Sample is selected and transported to designated area to perform swabbing. Sample is placed on the sterile plastic sheet.
4. Using clean disposable gloves, aseptically open swab container and remove one gauze swab, each container has 10 gauze swabs.
5. Hold the swab firmly and vigorously rub entire top surface of the packaging methodically from left to right, continue the process swabbing from the top to the bottom of the package. As per diagrams below.
6. Turn over product. Using same gauze swab continue to swab the now exposed bottom surface from left to right and then from top to bottom. Finally swab the sides of the packaging.
7. To ensure consistency of swabbing process please follow the instructions above.
8. After swabbing, place the swab into correctly labelled whirlpak bag. Roll down the whirlpak bag and turn in the ties, roll no more than three times.
9. Enter details onto the submission form. The paper copy of the submission form must be couriered with samples.
10. Discard plastic sheet used for sampling area prior to testing next sample.
11. Replace disposable gloves before next sample.
12. At the end of the swabbing all the samples from each supermarket, discard any opened gauze swab containers. DO NOT USE any gauze swabs from opened containers when sampling at the next supermarket.
13. If contamination is suspected during the sampling process, the sample must be discarded and a new sample taken.



Sampling of product

Place all product samples into individual plastic zip lock bags and attach the corresponding Cawthron pre-registered label with the unique sample ID. Enter the details onto the sample submission form which must be couriered with samples.

Packaging for transport

Place all samples in polybin with frozen ice packs above and below the samples to keep the samples cold. Do not freeze samples or swabs.

Courier with NZ Post preferably or NZ Couriers. Samples must be received within 30 hours of purchase. Samples to be sent to:

Cawthron Labs
Sample Reception
98 Halifax St East
NELSON 7010
Phone: 03 548 2839

Sample Submission Spreadsheet

Details pertaining to the sample to be entered into spreadsheet against the corresponding unique ID.

Appendix 2. List of codes used in the shared excel workbook for each of the collected samples (n=702). Location, product type, and the according number were used to give each sample a unique identifier.

Code	Meaning
AU	Auckland
CC	Christchurch
WLG	Wellington
WCH	Whole chicken
CHBoff	Skin-off chicken breast
OF	Offal items
OPCHB	Outside packaging of skin-off chicken breast

Example	Explanation
AU-WCH- 001	Whole chicken sample no. 1, collected from Auckland
AU-CHBoff- 001	Skin-off chicken breast no. 1, collected from Auckland
AU-OPCHB- 01	Swab from outside packaging of skin-off chicken breast no. 1, from Auckland
CC-CHBoff- 002	Skin-off chicken breast no. 2, collected from Christchurch
CC-OPCHB- 02	Swab from outside packaging of skin-off chicken breast no. 2, from Christchurch
WLG-OF- 03	Offal item no. 3, collected from Wellington
WLG-OPCHB- 03	Swab from outside packaging of skin-off chicken breast no. 3, from Wellington

Appendix 3. QSM 5 method 10.071B.

TITLE: *Campylobacter* in Retail Testing Survey MPI

KEYWORDS: *Campylobacter* , mCCDA

PREPARED BY: Pam Curtis, Ryan Hunter

DATE : 16th January 2024

1. PRINCIPLE OF METHOD

1.1. Purpose

- 1.1.1. To understand the sources and pathways of contamination, by *Campylobacter*, in the supply chain, and in particular to understand the levels of contamination of fresh meat sold at retail and the potential for cross-contamination via packaging.
- 1.1.2. To understand the risk and levels of exposure of *Campylobacter* to the consumer.

1.2. Scope

- 1.2.1. Test for the prevalence and concentration of *Campylobacter* in raw poultry at retail. Testing of the outside packaging of skin-off chicken breast products. All swabbing of the packaging will be performed by NZFS Food compliance officers using a procedure supplied by Cawthron.

1.1. Clarifications

- 1.1.1. All sampling will be performed by the NZFS Food Compliance team and shipped to Cawthron Laboratories for microbiological testing. Sampling plan will be developed by MPI. Products will be obtained from supermarkets raw, unfrozen, and contain at least 200g.
- 1.1.2. All samples will be shipped to Cawthron on ice and in poly/chilly bins. The temperature of samples will be measured upon receipt at the laboratory using a thermometer to ascertain the degree of temperature increase of samples. Samples with temperatures less than 0°C, or more than 10°C will be regarded as being non-compliant and rejected. Samples will need to arrive within 30 hours of collection from retail. Samples received outside of the specified time frame will be regarded as non-compliant and rejected. Samples will be held at 4°C in the laboratory until testing commences, which must be within 4 hours of arrival.
- 1.1.3. Samples enriched in Bolton Broth are to be incubated microaerobically using microaerophilic gas packs within suitable containers in Pathogen lab.
- 1.1.4. Testing of packaging swabs will be prioritised in the lab before the chicken breasts, whole birds or poultry offal for practical reasons.

2. MEDIA AND REAGENTS

2.1. Reagents

- Oxidase reagents
- Catalase reagent
- Gram stain reagents

2.2. Media

- 2.2.1. Buffered Peptone Water supplemented with 1ml of 3% sodium thiosulfate solution per 1L of Buffered Peptone Water.
- 2.2.2. Bolton Broth – ready-made; Antibiotics included.
Note: Stored in freezer until use. Before use, defrost and use when at ambient temperature. Validation of shelf-life VR040
- 2.2.3. *Campylobacter* Blood-free Agar (Modified Charcoal Cefoperazone Deoxycholate Agar; mCCDA) – ready-made; purchased.
- 2.2.4. 0.1% Peptone.
- 2.2.5. Sheep Blood Agar
- 2.2.6. Gauze swabs containing thiosulfate, tween 20 and peptone.

3. EQUIPMENT

- Ethanol 70%
- Sterile plastic sample bags
- Gloves
- Microaerophilic gas pack (AnaeroPack – MicroAero)
- Anaerobic jar/boxes
- Incubators: 42°C ± 1.0, 37°C ± 0.5
- Balance
- Centrifuge
- Sterile 50 ml centrifuge tubes
- Sterile 50 ml serological pipettes
- Vortex
- Cryo-beads (Microbank brand)

4. CONTROL CULTURES

Media		Organism	Result
Buffered Peptone Water Bolton Broth	Positive Control	<i>Campylobacter jejuni</i> NZRM 2397	Needs to be streaked out to confirm result.
mCCDA Agar	Positive Control	<i>Campylobacter jejuni</i> NZRM 2397	<i>Campylobacter</i> colonies on CCDA Agar are round to irregular grey colonies with smooth edges. They can show thick translucent growth to spreading film. A metallic sheen can sometimes be seen.
Blood Agar	Positive Control	<i>Campylobacter jejuni</i> NZRM 2397	<i>Campylobacter</i> colonies on blood agar are brown and translucent. A metallic sheen can sometimes be seen.

4.1. Store on beads in freezer.

Remove a bead, monthly, and store in Bolton Broth at 37°C.

5. ANALYTICAL PROCEDURE

Wash hands when entering and leaving laboratory. No immunocompromised or pregnant staff to work in Pathogen laboratory. No eating or drinking in lab. Wear blue lab coat.

5.1. Whole Chickens (Enumeration Only)

5.1.1. Wipe sample bag clean with 70% Ethanol before opening.

5.1.2. Transfer carcass aseptically from retail bag to rinse bag containing 400mL Buffered Peptone Water.

5.1.3. Expel most of the air from the bag and then secure the bag tightly by hand, to prevent losing any of the diluent.

5.1.4. Commence the whole carcass rinse procedure and begin timing. This must continue for 2 minutes to ensure complete coverage of both the external and internal surfaces of the carcass with the diluent, which becomes the “rinsate” when the rinse procedure begins. Begin by rocking the carcass in the bag in an arching motion to rinse the outside of the carcass, including the wings and legs. Transfer the weight of the carcass from one hand to the other while simultaneously massaging the carcass surface, particularly around the wings and legs. When the rinsate becomes yellowy in colour (with suspended fats), proceed to the next step.

Ensure that the cavity of the carcass is rinsed by periodically positioning the carcass so that the rinsate can enter.

Any fat or skin covering the vent may need to be cleared to enable rinsate to enter the cavity. Swirl the rinsate so that the entire internal cavity is rinsed and the rinsate on exiting from the cavity is a pink to red colour.

Continue rocking the carcass to pass the rinsate over the external and internal surfaces for the remainder of the 2 minutes. There should be at least 2 complete internal cavity rinses during the 2 minutes. On completion of the whole carcass rinse, check that the rinsate has a reddish tint and is thicker than the starting diluent due to the presence of suspended fats and visible cells. (NMD 4.8.3)

- 5.1.5. Transfer a 50mL aliquot to a centrifuge tube using a 50 ml serological pipette. Centrifuge for 30 minutes at 4430 x g.
- 5.1.6. Using a 50mL serological pipette, discard 45mL of the supernatant taking care not to disturb the pellet.
- 5.1.7. Resuspend the pellet in the remaining 5mL using a vortex apparatus for approx. 20 seconds on the highest setting. This is regarded as the 10^0 dilution.
- 5.1.8. Spread 2mL of the 10^0 suspension over 6 mCCDA plates.
- 5.1.9. Make 10 fold dilutions using 9mL buffered peptone tubes down to 10^{-1} and 10^{-2} . Plate out 0.1mL in duplicate onto mCCDA plates for 10^{-1} and if required 10^{-2} dilutions.
- 5.1.10. Incubate plates at $42^\circ\text{C} \pm 1.0$ in microaerobic conditions for 48hrs ± 2 hrs.

5.2. Skin-off Chicken Breast (Enumeration only)

- 5.2.1. Wipe sample bag clean with 70% ethanol before opening.
- 5.2.2. Aseptically transfer one portion of chicken breast from retail bag into rinse bag with 100mL of Buffered Peptone Water.
- 5.2.3. Expel most of the air from the bag and then secure the bag tightly by hand, to prevent losing any of the diluent.
- 5.2.4. Rinse sample for 2 minutes by transferring weight from hand to hand and massaging the meat. On completion check that the rinsate is thicker than the starting diluent due to the presence of suspended fats and visible cells.
- 5.2.5. Transfer a 50mL aliquot to a centrifuge tube using a 50 ml serological pipette. Centrifuge for 30 minutes at 4430 x g.
- 5.2.6. Using a 50mL serological pipette, discard 45mL of the supernatant taking care not to disturb the pellet.
- 5.2.7. the pellet.
- 5.2.8. Resuspend the pellet in the remaining 5mL using a vortex apparatus for 20 seconds on the high setting. This is regarded as 10^0 .
- 5.2.9. Spread 2mL of the 10^0 suspension over 6 mCCDA plates.
- 5.2.10. Make 10 fold dilutions using 9mL buffered peptone tubes down to 10^{-1} and if required 10^{-2} . Plate out 0.1mL in duplicate onto mCCDA plates for 10^{-1} and if required 10^{-2} dilutions.
- 5.2.11. Incubate plates at $42^\circ\text{C} \pm 1.0$ in microaerobic conditions for 48hrs ± 2 hrs.

5.3. Poultry Offal Items (Enumeration only)

- 5.3.1. Wipe sample bag clean with 70% ethanol before opening.
- 5.3.2. Aseptically transfer one portion or at least 10g into rinse bag with 100mL of Buffered Peptone Water. Use whole portions, do not cut portions.
- 5.3.3. Expel most of the air from the bag and then secure the bag tightly by hand, to prevent losing any of the diluent.
- 5.3.4. Rinse sample for 2 minutes by transferring weight from hand to hand and massaging the meat. On completion check that the rinsate is thicker than the starting diluent due to the presence of suspended fats and visible cells.

- 5.3.5. Transfer a 50mL aliquot to a centrifuge tube. Centrifuge for 30 minutes at 4430 x g.
- 5.3.6. Using a 50mL serological pipette, discard 45mL of the supernatant taking care not to disturb the pellet.
- 5.3.7. Resuspend the pellet in the remaining 5mL using a vortex apparatus for 20 seconds on the high setting. This is regarded as 10⁰.
- 5.3.8. Spread 2mL of the 10⁰ suspension over 6 mCCDA plates.
- 5.3.9. Make 10 fold dilutions using 9mL buffered peptone tubes down to 10⁻¹ and 10⁻². Plate out 0.1mL in duplicate onto mCCDA plates for 10⁻¹ and if required 10⁻² dilutions.
- 5.3.10. Incubate plates at 42°C ± 1.0 in microaerobic conditions for 48hrs ±2 hrs.
- 5.3.11. hrs.

5.4. Outside Packaging (Detected/Not Detected)

- 5.4.1. Swabbing performed by MPI samplers. Pre-moistened gauze swabs from the packaging are received by Cawthron in Whirlpak bags. On arrival at the laboratory add 50mL Bolton Broth.
- 5.4.2. Swabs are briefly massaged by hand to ensure swab is fully immersed.
- 5.4.3. Incubate at 37°C ± 0.5 for 4 hours, then at 42°C ± 1.0 for 44 hrs ±2 hrs.
- 5.4.4. Streak 0.1mL of the broth onto mCCDA plate.
- 5.4.5. Incubate 42°C ± 1.0 in microaerobic conditions for 48 hours ±2 hrs.

5.5. Plate Reading

- 5.5.1. *Campylobacter* colonies on mCCDA Agar are round to irregular grey colonies with smooth edges. They can show thick translucent growth to spreading film. *Campylobacter* colonies on blood agar are brown and translucent. A metallic sheen can be observed on both agar types.
- 5.5.2. Streak up to 5 suspicious colonies per sample to Blood Agar to ensure a pure culture for confirmations. Incubate blood agars microaerobically at 42°C ± 1.0 for 48 hours ±2 hrs to obtain single colonies.
Refrigerate mCCDA Agar microaerobically in case further analysis is necessary.

Confirmations

- 5.5.3. Perform catalase, oxidase and gram stain from blood agars.
 - 5.5.3.1. **Catalase** – Place a drop of 3% H₂O₂ onto a slide. Mix with a loopful of growth from blood agar. Bubbles indicate a positive test.
 - 5.5.3.2. **Oxidase** – Rub loopful of growth from blood agar onto oxidase paper. If paper turns purple it is oxidase positive. Use a positive oxidase control – *Pseudomonas aeruginosa*. *Campylobacter* spp. are catalase and oxidase positive.
 - 5.5.3.3. **Gram stain** – Pick one typical colony per plate. Emulsify colony in a drop of saline. Perform gram stain. *Campylobacter* cells are thin, curved, gram negative rods often forming zigzag shapes.
- 5.5.4. A representative isolate from each positive sample will be sent for identification by MALDI-ToF at Massey University.
- 5.5.5. The same isolate that is to be identified by MALDI-ToF will be stored on cryo-beads at -80°C for further testing if required.

5.6. Result Calculation

- 5.6.1. Whole carcass calculation

$$\text{CFU/carcass} = (\text{number of typical } \textit{Campylobacter} \text{ morphology colonies in 2 ml}) \times (\text{rinsate volume; 400 ml}) / 20$$
 (because 2 of 5 ml of resuspended pellet is plated which arose from 20 ml rinsate assuming 10-fold concentration in pellet) x 1/dilution.

E.g. if 1 colony present over 2 ml concentrated plated rinsate, arising from 400 ml total rinsate, there are $1 \times 20 = 20$ CFU/**carcass**.

5.6.2. Breast or Offal calculation

CFU/breast or offal = (number of typical *Campylobacter* morphology colonies in 2 ml) x (rinsate volume; 100 ml)/20 (because 2 of 5 ml of resuspended pellet is plated which arose from 20 ml rinsate assuming 10-fold concentration in pellet) x 1/dilution.

E.g. if 1 colony present over 2 ml concentrated plated rinsate, arising from 100 ml total rinsate, there are $1 \times 5 = 5$ CFU/**portion**

5.6.3. Gauze Swab = for a Detect result confirmation of a colony as *Campylobacter* is required.

5.7. Detection limit

5.7.1. Whole chicken carcass using centrifugation method if correction for CFU lost in supernatant **is not** considered: The theoretical method detection limit of the centrifugation experiment assuming that all *Campylobacter* CFU are contained in the cell pellet and retained in 5 ml of supernatant is 20 CFU per 400 ml (1 CFU per 20 ml).

5.7.2. Chicken breast or Offal using centrifugation method if correction for CFU lost in supernatant **is not** considered: The theoretical method detection limit of the centrifugation experiment assuming that all *Campylobacter* CFU are contained in the cell pellet and retained in 5 ml of supernatant is 5 CFU per 100 ml (1 CFU per 20 ml).

5.7.3. Swabbing of outside packaging – Detect/Not Detected result will have a DL of 1CFU/swab.

6. RESULTS

6.1. Reporting.

6.1.1. Report as Detected/ Not detected per swab per packaging (no units required)

6.1.2. Enumeration reported as CFU/carcass or CFU/portion

7. REFERENCES

7.1. Reporting References:

7.1.1. MPI Centrifugation Method (internal use only)

7.1.2. FDA Bacteriological Analytical Manual online version

7.2. Technical References:

7.2.1. **NMD MPI: Animal Products Notice: Specifications for National Microbiological Database Programme (current edition)**

8. HAZARDS

Campylobacter species are highly infective. The infective dose of *C. jejuni* ranges from 500–10,000 cells, depending on the strain, environmental stresses and the susceptibility of the host. *C. jejuni* can survive 2–4 weeks under moist, reduced-oxygen conditions at 4°C, often outlasting the shelf-life of the product. They can survive 2–5 months at –20°C, but only a few days at room temperature (depending on the matrix in which they are present).

APPENDIX

CHART 1: BIOCHEMICAL TESTS

Characteristic	<i>C. jejuni</i>	<i>C. jejuni</i> Subsp <i>doylei</i>	<i>C. coli</i>	<i>C. lari</i>	<i>C. fetus</i>	<i>C. hyo-intestinalis</i>	<i>C. upsaliensis</i> *
Catalase	+	+	+	+	+	+	+
Oxidase	+	+	+	+	+	+	+
Gram	-ve rod	-ve rod	-ve rod	-ve rod	-ve rod	-ve rod	-ve rod

Symbols: + 90% or more of strains are positive

- 90% or more of strains are negative

* "*C. upsaliensis*" (proposed name) will not grow in media containing antibiotics