Managing Microbiological Food Safety Risks in Poultry Processing

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Introduction

The poultry industry has undergone extraordinary expansion over the last several decades, growing into the No. 1 meat consumed in the United States.1 Poultry production has evolved from primarily whole and cut-up chicken and eggs sourced from family farms and sold through traditional grocery stores into a multitude of further-processed, convenient products available through numerous points of purchase. U.S. consumers today can find microwavable chicken dinners, turkey deli meats, liquid-pasteurized eggs and more from local, convenience retailers. Meanwhile, chicken sandwiches and boneless wings have become fast food sensations.

With the readily available resources, consumers have become aware and interested in where their food comes from. Consumers of poultry meat products love the offerings but want them to be safe for consumption, thus making processors more accountable for the foods manufactured. Food processors continue to improve their processes to provide safe food as regulations evolve over time. Regulators want to assure consumers that the food is suitable to eat as consumers’ main concern is pathogen contamination.2

From a food safety perspective, the vertically integrated nature of the poultry industry has increased the responsibility of poultry companies to manage the microbiological safety of their products as they travel through the production continuum. Vertical integration of poultry production has enabled poultry companies to reach economies of scale by owning and operating their complete business lifecycle (everything from the breeder flocks, hatcheries and feed mills to the processing plants and transportation methods to sales and marketing). Known as “integrators”, large companies own the majority of poultry produced, contracting with independent farms to raise their birds to meet processors’ defined criteria. The integrators need to monitor food safety hazards – especially Salmonella and Campylobacter prevalence – from live bird holding to evisceration, processing, packaging and shipping.

To verify process control in meat and poultry slaughter and processing establishments, the U.S. Department of Agriculture Food Safety and Inspection Service (USDA FSIS) established its Salmonella verification program and performance standards in 1996 as part of the Pathogen Reduction Program.3 The performance standards were established based on national baseline studies and applied only to carcasses.

As part of continuing advancements to the monitoring program, USDA FSIS revised the Salmonella and Campylobacter performance standard program in 20164 and 2019.5 These new standards constitute one component of Healthy People 2020, a massive public health and awareness initiative coordinated by the U.S. Department of Health and Human Services’ Office of Disease Prevention and Health Promotion that aims to measurably improve nationwide health and prevent disease.6 Significant attention has been dedicated to efforts to reduce foodborne illnesses in the population, particularly Salmonella, Campylobacter, Listeria and E. coli O157.

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The revised performance standard replaced a *Salmonella*-specific sampling set approach with a routine sampling approach for all USDA FSIS regulated products subject to *Salmonella* and *Campylobacter* verification testing. This includes broiler and turkey carcasses, chicken parts and not-ready to eat (NRTE) comminuted poultry. Current *Salmonella* and proposed *Campylobacter* performance standard verification samples are now taken as part of a “moving window” (reference period of one completed 52-week moving window) sampling approach, with the results used to determine if an establishment meets the performance standard on a continuous basis.

USDA estimates that the new standards will prevent about 50,000 illnesses each year. This program has created new limits on the number of product samples that test positive for a pathogen. For example, the new *Salmonella* standards require contamination rates of no more than 25% in comminuted chicken, 13.5% in comminuted turkey, and 15.4% in chicken parts. Table 1 lists USDA FSIS performance standards for *Salmonella* and proposed performance standards for *Campylobacter* within various types of poultry. The final revised performance standards are published in the U.S. Federal Register.

### Table 1: Performance standard for *Salmonella* and *Campylobacter* in poultry

<table>
<thead>
<tr>
<th>Sample</th>
<th>Minimum acceptable percent positive</th>
<th>Performance standard**</th>
<th>Minimum number of samples to assess process control</th>
<th>Maximum acceptable percent positive</th>
<th>Performance standard</th>
<th>Minimum number of samples to assess process control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broiler Carcass</td>
<td>9.8</td>
<td>5 of 51</td>
<td>11</td>
<td>15.7</td>
<td>8 of 51</td>
<td>10</td>
</tr>
<tr>
<td>Turkey Carcass</td>
<td>7.1</td>
<td>4 of 56</td>
<td>14</td>
<td>5.4</td>
<td>3 of 56</td>
<td>19</td>
</tr>
<tr>
<td>NRTE Comminuted Chicken (325 g sample)</td>
<td>25.0</td>
<td>13 of 52</td>
<td>10</td>
<td>9.6</td>
<td>5 of 52</td>
<td>11</td>
</tr>
<tr>
<td>NRTE Comminuted Turkey (325 g sample)</td>
<td>13.5</td>
<td>7 of 52</td>
<td>10</td>
<td>9.6</td>
<td>5 of 52</td>
<td>11</td>
</tr>
<tr>
<td>Chicken Parts (4 lb, 1.81 Kg)</td>
<td>15.4</td>
<td>8 of 52</td>
<td>10</td>
<td>7.7</td>
<td>4 of 52</td>
<td>13</td>
</tr>
</tbody>
</table>

*Campylobacter performance has not been implemented yet | **Number of samples allowed to be positive out of total number of samples analyzed

This whitepaper outlines the possible sources of *Salmonella* and *Campylobacter* contamination in poultry processing establishments. It addresses where and how monitoring and control strategies can be enhanced to help processors meet the current performance standards for *Salmonella* and proposed performance standards for *Campylobacter*, and which meaningful data can be gathered to help processors continuously improve their processes to reduce the risk of contamination.

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Contamination sources

Microbial contamination of the broiler or turkey carcasses can originate either from (1) the external surfaces of the birds such as the feathers and skin, or (2) the internal gut contents during evisceration process, resulting in cross-contamination of other carcasses. Birds’ exterior surfaces, including the skin can bring *Salmonella* and *Campylobacter*, as well as other microorganisms from the farm into processing facilities. In both cases (external or gastrointestinal sources of contamination), *Salmonella* and *Campylobacter* are an integral part of the microbiota along with other commensal microorganisms. Several *Salmonella* outbreaks have been linked to poultry products.\(^8\) The outbreak of *Salmonella* Reading in turkey products and *Salmonella* Infantis in raw chicken products\(^9\) in 2018 resulted in hundreds of cases across multiple states, leading to hospitalizations and even one death related to each.

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Pathogen control and interventions

Proper management of the various steps of processing with the addition of antimicrobial intervention steps will help poultry companies meet the performance standards and reduce the contamination levels. Poultry processors need to track and monitor the contamination sources so that they can implement and assess effective intervention strategies.

USDA FSIS stipulates that poultry companies sample their whole-bird carcasses for *Salmonella* and *Campylobacter* subsequent to chilling. The cut-up products must be similarly sampled. The test results from this late-stage sampling provide information on the cumulative effectiveness of the preceding intervention efforts. However, a positive result does not give any insight into the problem areas where intervention may not have been effective.

In the absence of a single, definitive microbiological kill step, processors of raw poultry products rely on a combination of antimicrobial interventions and applications strategically sequenced throughout the processing environment to reduce the prevalence of *Salmonella* and *Campylobacter* in their products. These include, but are not limited to, acidifiers in scald tanks, chlorine-based compounds or other formulated sprays after feather-picking, on-line reprocessing sprays or dips following evisceration and, certainly, chilling at proper time and temperatures with further use of antimicrobial sprays.

**Figure 1** (page 5) depicts the difficulty of this “multi-hurdle” intervention approach to managing microbial loads. The process involves numerous steps, starting with hanging of the birds and on to various chilling practices. Contamination and/or cross-contamination of the carcasses or parts can occur at any stage prior to or after the antimicrobial intervention steps.

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There are three processing steps where cross-contamination risks are greater: scalding, picking and evisceration.

Scalding is where hot water loosens follicles so that the bird carcasses’ feathers can be subsequently removed by picking machinery. At this critical stage, cross-contamination of the carcass may occur and open feather follicles can become filled with dirty water containing pathogens and other microorganisms from the scalder.

In picking, one carcass can become cross-contaminated by another, as well as by workers or equipment. Carcasses travel through a series of defeathering machines consisting of rotating disks or drums mounted with rubber fingers that pluck the birds’ plumage. Not only can these fingers massage dirty water remaining from the scalder into the carcass, they can force the cloacal contents (feces) out, resulting in transfer of microorganisms to the skin or to the machinery.

Another high-risk step is evisceration. When processors open birds’ GI contents, there is heightened risk of cross-contamination due to gut breakage and transfer of the contents to the skin and other carcass surfaces. Processors must also make sure any knives or implements used in this process are constantly cleaned and sanitized to prevent cross-contamination.
**Tips for chilling**

One more key consideration to keep microorganism levels low involves immersing the poultry into water with antimicrobials or hanging and spraying them with antimicrobials. In the case of the former, cross-contamination in the chiller water poses a threat. While not always practiced, processors are wise to constantly manage the water’s temperature, pH balance and softness as well as the kind and concentration of the antimicrobial. For air chilling, processors should take precautions to prevent drip contamination from poorly designed processing lines. For example, the processing lines (for carcasses chilling) physically above of the poultry chiller(s) can result in drip contamination. This becomes important because FSIS uses the post-chill carcasses to determine the prevalence of *Salmonella* and *Campylobacter*.

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**Verifying process control steps with indicator tests**

Robust process control within poultry production is critical and provides insights into which specific processing steps need more attention to better control and reduce pathogen contamination. In addition to testing for the pathogens directly, many processors utilize other indicator organisms that can be predictive of pathogen prevalence.

The USDA FSIS recommends testing for *generic E. coli* as a method to verify process control. Many processors also leverage aerobic plate count and *Enterobacteriacea* counts to predict and control *Salmonella* and *Campylobacter* prevalence. To enhance the effectiveness of these efforts, USDA FSIS has issued a guidance document on the use of these indicator organisms as predictors of *Salmonella* and/or *Campylobacter* contamination at various processing steps. Tables 2 and 3 show the median values for indicator organisms for chickens and turkey, respectively. While these Tables provide a guidance, the poultry processors should collect their own data to develop these guidelines for process control in their operations.

**Table 2. Example indicator organism median values for chickens**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Generic E. coli</th>
<th>APC</th>
<th><em>Enterobacteriacea</em></th>
<th>Total coliform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass - Rehang</td>
<td>540</td>
<td>28,000</td>
<td>1,600</td>
<td>940</td>
</tr>
<tr>
<td>Carcass - Post chill</td>
<td>20</td>
<td>260</td>
<td>20</td>
<td>20</td>
</tr>
</tbody>
</table>

**Table 3. Example indicator organism median values for turkeys**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Generic E. coli</th>
<th>APC</th>
<th><em>Enterobacteriacea</em></th>
<th>Total coliform</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carcass - Rehang</td>
<td>22</td>
<td>1,800</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Carcass - Post chill</td>
<td>&lt;1.2</td>
<td>18</td>
<td>&lt;1.2</td>
<td>&lt;1.2</td>
</tr>
</tbody>
</table>

* Rinse samples are tested for bacterial counts

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Process control indicator *E. coli* (or other indicator microorganism) testing is typically conducted subsequent to the chilling process. This satisfies the HACCP requirement to perform monitoring-based “verification” that control measures of key hazards are continuously effective. Beyond this requirement, as a best practice, poultry companies should also conduct sporadic sampling and testing – for *E. coli*, aerobic counts and *Enterobacteriaceae*, or directly for *Salmonella* and *Campylobacter* – more universally throughout processing. This helps check control parameters, trouble-shoot breakdowns and/or assess the viability and comparability of new antimicrobial interventions available from suppliers.

As a best practice, a combination of tests should be leveraged to systematically “biomap” (Figure 2) product contamination at selected processing steps and determine the increase or decrease in the levels of contamination at each point. This can also reveal the efficacy of the antimicrobial interventions at specific steps and the combined effects of all the steps on the final product contamination levels, using indicator testing. Sampling plans should meet individual needs and adequately cover the entire process. Ideally, sampling should be done at different times and shifts within a given workday, week or month with a strong consideration given to randomized sampling.

**Figure 2:**
**Biomap for poultry processing**
Key Considerations for Designing Process-Specific Biomaps

1. How should the location(s) be selected?
   Select sites for potential for contamination or reduction/elimination of contamination

2. How many samples should be collected?
   Sufficient samples to get a picture of the process

3. When (time of day, work shift) should sampling occur?
   Ideal to distribute sampling over the day, week and month

4. What specifically should we sample for?
   Indicators (concentration) vs. pathogens (prevalence)

5. How will the data be leveraged?
   Use data to develop actionable information tracking and trending over time to improve process

Last but not least, processors should methodically record and maintain the results, tracking trends and implementing changes or corrective actions where necessary. For example, a processor that is able to regularly identify spikes in Campylobacter prevalence as their products arrive to the main chiller may choose to augment their processing with incorporation of a pre-chiller or a post-chill dip tank as an additional antimicrobial intervention step. Once the new equipment is installed, the processor needs to demonstrate that this added processing step is achieving the intent to help reduce levels of a microorganism of concern at the specific production step as well as the entire process.
Poultry meat consumption is rapidly growing as distribution channels expand and consumer demand intensifies. Poultry processors need to make sure they are meeting regulatory performance standards and are providing safe food. The efforts will lead to decreased outbreaks and help achieve the health goals set by government agencies.

Processors need to regularly check their control parameters, specifically as they relate to levels of *Salmonella* and *Campylobacter* prevalence and levels of indicator organisms. These can paint the overall microbiological picture of their multi-step processing environments. Hygiene control must be optimized throughout the process, and regular sampling, monitoring, record-keeping and data trending are all essential.

The key to process evaluation is to support sequenced antimicrobial interventions throughout the production continuum with smart microbiological sample collection, monitoring and detection in everything from live birds to carcasses to contact surfaces. Many commercially available diagnostic tests exist to provide insight into the failures of process controls, the nature of contamination and where corrective actions should be implemented. However, just as processors must confirm the suitability and efficacy of any antimicrobial solutions to their unique environment, they’ll also want to ensure that the test methods they utilize fulfill their organizations’ needs and objectives. The validated test methods should be fit for intended purposes and application.

Last but not least, poultry processors must always keep in mind that simply possessing information about food safety hazards isn’t enough. They must convert that knowledge into action, interpreting test results into the context of trends over time, the potential for process improvements and the efficacy of any such improvements made. In today’s rapidly growing marketplace of big data, connected software and the Internet of Things, poultry processors are entering a new frontier of possibility to ensure the safe production and fulfillment of their increasingly popular poultry meat offerings.

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