National Pork Retail
Microbiological Baseline

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Introduction

Several studies have either been completed or are currently in progress to determine the presence of indicator and/or pathogenic microorganisms on pork carcasses.\(^1\,^2\,^3\) Investigations such as these have increased our understanding of the populations and species of microorganisms that may be found on pork due to cross-contamination or poor handling/processing practices. Most studies have concentrated on the carcass; however, pork can subsequently be re-contaminated with bacteria during fabrication, packaging, distribution, and retail preparation and, therefore, more information on contamination levels and pathogen incidences following such practices must be gathered.

The purpose of this study was to evaluate microbiological contamination (including microbiological plate counts and pathogen incidence) occurring on pork products at the wholesale and retail level to facilitate the assessment of microbiological risks associated with pork retail products. By sampling the final, finished goods, which display the combined effects of all processes before the purchase of pork by consumers, the hazards associated with pork products can be examined. The specific objectives of this study were to determine Aerobic Plate Counts (APC), Total Coliform Counts (TCC), *Escherichia coli* Counts (ECC), and the incidence (presence/absence) of *Salmonella* spp., *Listeria monocytogenes*, *Yersinia enterocolitica*, and *C. jejuni/coli* in (I) freshly-ground pork and/or pork sausage products processed in three types of processing plants (hot-boned, sow/boar, sausage plants, slaughter/fabrication plants, and further-processing plants) and (II) on four types of retail pork products collected from retail stores in six continental U.S. cities.

Materials and Methods

To achieve Objective I of this study, twenty samples of freshly-ground pork and/or freshly-ground pork sausage were collected from six processing facilities from different geographic regions throughout the US (West Coast, Mid-West, South-Central, South and East Coast) during a two-day period in each plant (120 samples total). The pork processing facilities included two hot-boning, sow/boar, sausage plants, two fed hog slaughter/fabrication plants, and two further-processing plants. Hot-boning, sow/boar sausage plants processed warm meat and fat, from sows and boars, directly after slaughter and dressing. The fed hog slaughter/fabrication plants processed fat and lean trimmings from chilled carcasses of fed hogs slaughtered at the facility. Ground pork and/or pork sausage produced at the further-processing facilities were manufactured from chilled or frozen pork trimmings purchased from another facility.
To achieve Objective II of this study, 384 samples of retail pork products, wrapped for sale and displayed in the retail merchandising case, were collected from four retail stores in each of the six cities; 24 stores total. The pork products sampled were: (a) whole-muscle, store-packaged (tray and polyvinyl chloride film overwrap), pork retail cuts; (b) fresh, store-ground and store-packaged pork and/or pork sausage (paper-wrapped or tray and polyvinyl chloride film overwrap); (c) pre-packaged (at the processing plant) ground pork and/or pork sausage, and (d) whole-muscle, enhanced (injected with a brine solution; pre-packaged under vacuum or store-packaged in trays and overwrapped with polyvinyl chloride film) pork cuts.

Results and Discussion

As shown in Table 1, for ground pork and/or pork sausage samples collected in pork plants, overall microbiological contamination (Aerobic Plate Counts / APC) and fecal contamination (Total Coliform Counts/TCC) were higher in ground products from slaughter/fabrication plants than from the other types of facilities (plants that only produced ground or processed pork). Mean generic Escherichia coli Counts (ECC) were lower in the further-processing plants. Also shown in Table 1, for pork samples collected at retail supermarkets, microbial contamination was higher in products that had been handled more extensively in the store (e.g., the store-processed and packaged ground and whole-muscle pork products). Store-ground pork may also have higher bacteria counts due to the initial bacteria load on pork trimmings or cuts used for grinding in the store. Less microbial contamination (APC, TCC, and ECC) was found on whole-muscle, enhanced (injected) products than non-enhanced, whole-muscle products, possibly due to the anti-microbial effects of the enhancing agents—which were primarily composed of water and sodium phosphate or sodium lactate, along with other ingredients—or because of how the whole-muscle, enhanced products were packaged (60% were store-packaged, 40% were pre-packaged under a vacuum before distribution to the retail stores). Centrally packaging or pre-packaging retail cuts can reduce the chances of cross-contamination that are present during retail packaging.

Listeria monocytogenes was the most common pathogen detected in the samples of freshly-ground pork product collected from plants of all types and the highest incidence occurred in the further-processing

<table>
<thead>
<tr>
<th>Product</th>
<th>n</th>
<th>Salmonella spp.</th>
<th>L. monocytogenes</th>
<th>Y. enterocolitica</th>
<th>C. jejuni/coli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground Pork and/or Sausage</td>
<td>n</td>
<td>Salmonella spp.</td>
<td>L. monocytogenes</td>
<td>Y. enterocolitica</td>
<td>C. jejuni/coli</td>
</tr>
<tr>
<td>Hot-Boning Sow/Boar</td>
<td>40</td>
<td>10.0</td>
<td>12.5</td>
<td>0.0</td>
<td>12.5</td>
</tr>
<tr>
<td>Slaughtering/Fabricating</td>
<td>40</td>
<td>7.5</td>
<td>32.5</td>
<td>7.5</td>
<td>0.0</td>
</tr>
<tr>
<td>Further-Processing</td>
<td>40</td>
<td>0.0</td>
<td>35.0</td>
<td>2.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Total</td>
<td>120</td>
<td>5.8</td>
<td>26.7</td>
<td>3.3</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Table 1. Pathogen incidence in samples of ground pork and/or sausage collected from three types of plants (percentage of samples that tested positive for each pathogen).
and slaughter/fabrication plants (35.0% and 32.5% of samples were positive for *L. monocytogenes*, respectively—Table 2). *Listeria monocytogenes* was also the most common pathogen found across all retail pork samples (19.8% incidence—Table 3) and was present more frequently in ground product (store-ground and pre-packaged, ground pork) than in whole-muscle products (whole-muscle, store-packaged pork and whole-muscle, enhanced pork).

*Listeria monocytogenes* is known to have the ability to attach to different surfaces, such as stainless steel, glass and rubber. Furthermore, this organism can form a biofilm on such surfaces that can be resistant to various sanitizers. The ground pork in this study may have been contaminated from improperly cleaned grinding and processing equipment. Proper efforts need to be made to maintain strict prerequisite Good Manufacturing Practices, Standard Operating Procedures, and Sanitation Standard Operating Procedures to ensure that grinding and mixing equipment used in the production of ground pork or sausage is cleaned correctly before each use and that product is not re-contaminated or abused during processing and handling.

Contamination with *Yersinia enterocolitica* appeared to occur after the product left the plant, during further processing in retail stores. It was detected most often in whole-muscle, store-packaged cuts (19.8% incidence—Table 3) and in store-ground product (11.5% incidence—Table 3). Higher levels of this bacteria at the retail level could have been due to the additional growth of this cold-tolerant organism during display. Overall, there was a very low incidence of *Salmonella spp.* (9.6% across all products—Table 3), which agrees with recently released USDA Performance Standard Surveillance data, and *Campylobacter jejuni/coli* (1.3% across all products—Table 3) in pork retail products.

**Conclusions and Implications**

Pork products exposed to more extensive handling and processing (e.g., products processed at the retail store or products that are ground) appeared in this study, to be of lower microbiological quality than products processed at the plant and non-ground products. Good Manufacturing Practices and Sanitation Standard Operating Procedures are important for reducing microbiological contamination on pork products. Retail stores need to implement quality assurance programs or improve upon programs already in place, as was evident by the higher microbiological contamination in store-processed and packaged products. It is likely that development of retail HACCP plans would be beneficial to ensure the safety of pork products. Furthermore, supermarket operations should take a closer look at how completely they are cleaning and sanitizing grinding equipment. Further studies would be warranted to identify means for more completely removing bacterial contamination from equipment in both processing plants and retail stores.

**References**