Research Note

A Survey of the Microbiological Quality of Kangaroo Carcasses Processed for Human Consumption in Two Processing Plants in Queensland, Australia

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ABSTRACT

An investigation of the microbiological quality of kangaroo carcasses at two Queensland processing plants was carried out. A total of 836 whole muscle samples were taken, 801 from plant A and 35 from plant B. Samples were analyzed for aerobic bacteria, Escherichia coli, and Salmonella. The mean adjusted aerobic plate count (APC) was 2.8 log CFU/g, and counts at the 90th, 95th, and 99th percentiles were 4.2, 4.9, and 6.4 log CFU/g, respectively. The maximum number of bacteria recovered was 6.5 log CFU/g. E. coli was detected in 13.9% of samples, for which the adjusted mean was 0.7 log CFU/g, and counts at the 90th, 95th, and 99th percentiles were 1.4, 2.0, and 3.0 log CFU/g, respectively. Salmonella was detected in 0.84% of samples. There was no significant relationship (P < 0.05) between season and APC or E. coli count. There was a significant relationship (P < 0.001) between Salmonella prevalence and summer. The microbiological quality of Queensland kangaroo carcasses is similar to that obtained during other excision-based studies of kangaroo, wild boar, and beef carcasses.

Kangaroo meat has a nutritional profile (low fat and high levels of conjugated linoleic acid) that makes it an attractive health food alternative to other meat products (15). Five species of kangaroo are commercially harvested on mainland Australia; the kangaroo industry does not harvest endangered species (10). Harvest numbers are controlled by an annual quota determined by the Australian Government based on aerial population surveys (9). Animals are field dressed and chilled prior to transport to the processing plant. Carcasses are transported in refrigerated trucks to government approved meat processing establishments with approved quality assurance systems and hazard analysis critical control point (HACCP) programs. Carcasses are inspected by government veterinarians, fully eviscerated, skinned, washed, reinspected and chilled before boning. Prime cuts and manufacturing meat is sold in Australia to the food service industry and at retail outlets for human consumption. These products also are exported to many overseas markets.

Few studies dealing with the hygienic quality of kangaroo carcasses have been published. The objective of this study was to report on the microbiological quality of Red Kangaroo (Macropus rufus) and Eastern Grey Kangaroo (Macropus giganteus) carcass surfaces from which samples were collected in two Australian boning rooms by the excision method. The microbiological quality of these carcasses was compared with published Australian data for kangaroo, wild boar, and beef carcasses.

MATERIALS AND METHODS

Sampling. One large and one small to medium boning room in Queensland were selected for evaluation in this study. The boning rooms were under the control of the Australian Quarantine and Inspection Service and supplied prime cuts and manufacturing meat to overseas and domestic markets. Species processed were primarily Red Kangaroo and Eastern Grey Kangaroo. Field dressed and chilled animal carcasses were received at no more than 7°C. Between February 2003 and February 2006, samples were collected from dressed carcasses after the final operation and before entry into the boning room (5). Dressed carcasses were chilled at less than 5°C for 1 to 3 days before sampling. Samples (5 by 5 cm) weighing approximately 25 g were excised at the forequarter and rump area and pooled. Sampling equipment (knives and hooks) was sanitized in hot water (82°C) for 20 s between samples. Samples were transported to the laboratory in hard insulated containers. Upon arrival at the laboratory, which was accredited by the National Association of Testing Authorities, Australia, the sample temperature was measured. Samples with temperatures greater than 5°C were discarded.

Microbiological Analysis. Within 24 h of collection, 10 g of each pooled sample (composed of 5-g subsamples of forequarter and rump) was homogenized by stomaching with 90 ml of 0.1% sterile peptone solution (Interscience, St. Nom, France) for 1 min. Appropriate dilutions were plated on dry rehydratable film (aerobic plate count [APC] petrifilm, 3M, St. Paul, Minn.). Samples were also inoculated into tubes of lauryl tryptose broth (Amyl Media, Melbourne, Australia) containing Durum tubes for esti...
mation of the *Escherichia coli* count from a three- by three-tube most-probable-number (MPN) protocol. Petrifilm plates were incubated at 35°C for 48 h, and APCs were conducted according to the manufacturer’s instructions following AOAC method 990.12 (6). The limit of detection on petrifilm was <100 CFU/g. Incubated lauryl tryptose broth tubes were incubated at 37°C for 48 h. For samples that exhibited growth and gas production, active culture was inoculated into EC broth (Amyl Media) and incubated at 44.5°C for 48 h. For samples that produced a presumptive positive reaction for *E. coli* (growth and gas production), active culture was streaked onto eosin methylene blue agar (Amyl Media) and incubated at 37°C for 24 h. Dark purple colonies with a green metallic sheen were inoculated into tryptone water (Amyl Media), incubated at 44.5°C for 24 h, and tested for indole production. The MPN of *E. coli* in indole-positive broths was then estimated (2, 3). The limit of detection for the *E. coli* method was <3 MPN/g. Counts were converted to log CFU per gram. APCs were incremented by 100 CFU/g before log transformation so that non-detections were assigned a log value of 2. *E. coli* counts were incremented by 3 MPN/g prior to log transformation so that non-detections were assigned a log value of 0.4.

Samples were examined for the presence of *Salmonella* using an automated PCR system (BAX, DuPont Qualicon, Wilmington, Del.). For each pooled sample, 25 g (composed of two 12.5-g subsamples of forequarter and rump) was enriched in 225 ml of buffered peptone water (BPW) for 24 h at 35°C. Enrichment cultures were then analyzed using the automated PCR system according to the manufacturer’s instructions following the AOAC method 2003.09 (7). Presumptive-positive samples were confirmed by streaking retained BPW cultures onto xylose lysine deoxycholate (XLD) agar (Amyl Media) and bismuth sulfite agar (BSA; Difco, Becton Dickinson, Sparks, Md.). XLD and BSA plates were incubated at 37°C for 24 h and for 24 plus 48 h, respectively. Typical colonies were streaked on cystine lactose electrolyte-deficient medium (Amyl Media) and incubated at 37°C for 24 h. *Salmonella* was confirmed biochemically and serologically using Microbact 24E strips (Medvet Science, Adelaide, Australia) and the Serobact *Salmonella* latex agglutination kit (Medvet Science). *Salmonella* isolates were cultured onto plate count agar (Amyl Media) and sent to the Queensland Public Health Laboratory (Brisbane, Australia) for serotyping. Results were reported as detected or not detected in 25 g.

**Statistical analysis.** The relationship between the APCs and the *E. coli* seasonal counts was analyzed by t test (α = 0.05) using the Analysis ToolPak embedded in Microsoft Excel 2000 (Microsoft, Redmond, Wash.). The relationship between *Salmonella* prevalence and season was analyzed by the chi-square test using the CHITEST formula in Microsoft Excel 2000.

**RESULTS AND DISCUSSION**

**Microbiological profile.** Microbiological data for 836 kangaroo carcass samples obtained at two Queensland processing plants between February 2003 and February 2006 are presented in Table 1. *Salmonella* serotypes isolated were Emmastad, Rubislaw, Eastbourne, Muenchen, Havana, Saintpaul, and Reading.

**Seasonal effects and public health significance.** Because this survey was conducted for 3 years, seasonal effects were investigated. In earlier studies, significant seasonal effects in the microbiology of field harvested kangaroos were noted (8). These effects may have been mitigated by wet weather soiling of hides and downstream carcass contamination. In this study, there was no significant association (P < 0.05) between season and APCs or *E. coli* counts. A significant relationship (P < 0.001) was noted between *Salmonella* prevalence and summer. All *Salmonella*-positive samples were collected in January and February (midsummer in the Southern Hemisphere). The lack of seasonal trends for APCs and *E. coli* counts is suggestive of a different route of carcass contamination by *Salmonella*. It is not known why carcass contamination expected to be associated with wet weather was not found; one factor may be reduced harvesting of soiled kangaroos when wet weather affects unpaved roads and reduces access for hunters. The association between *Salmonella* and summer carcass contamination may be related to an animal carriage effect or to a temperature-sensitive postharvesting practice, e.g., cross-contamination of exposed meat from carcasses hanging on frames in field-harvest vehicles.

There have been no reported foodborne outbreaks of *Salmonella* infection in Australia linked to consumption of kangaroo meat up to December 2006 (11). Given the low consumption of kangaroo meat, it is improbable that a link, even if it existed, could be demonstrated by epidemiological data alone.

**Comparison with other studies.** There is remarkably little published information on the microbiology of kangaroo carcasses. In a 1964 South Australian survey of 36 kangaroo mince samples produced for pet consumption (1), *Salmonella* prevalence was 58%. In a 1991 Queensland survey of 84 kangaroo carcasses sampled by excision (8), the APC was 5.2 log CFU/g and *Salmonella* prevalence was 11%. Although comparison between studies is difficult because of different locations and methodologies, the microbiological quality of kangaroo carcasses as found in the present study is vastly improved from that reported in these earlier works. In the absence of published data on kangaroo carcasses, comparison can be made with data derived from other field-harvested animals from which excision carcass samples have been collected. In a 1991 study of 154 feral pigs (8), the *Salmonella* isolation rate was 34%. In a recent study of 217 Australian wild boar carcasses (unpublished

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>Prevalence (%)</th>
<th>Mean</th>
<th>Median</th>
<th>SD</th>
<th>90th percentile</th>
<th>95th percentile</th>
<th>99th percentile</th>
<th>Maximum</th>
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</thead>
<tbody>
<tr>
<td><em>Salmonella</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Aerobic bacteria</td>
<td>68.7</td>
<td>2.8</td>
<td>2.5</td>
<td>1.0</td>
<td>4.2</td>
<td>6.4</td>
<td>6.5</td>
<td></td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td>13.9</td>
<td>0.7</td>
<td>0.5</td>
<td>1.4</td>
<td>2.0</td>
<td>3.0</td>
<td>3.0</td>
<td></td>
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</tbody>
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* Limit of detection for the APC was 100 CFU/g. All counts were increased by 100 CFU/g before log transformation.

* Limit of detection for the *E. coli* MPN estimate was 3 MPN/g. All counts were increased by 3 MPN/g before log transformation.
data), the *E. coli* prevalence was 19.4% (compared with 13.9% in the present study), and the *Salmonella* isolation rate was 1.38% (compared with 0.84% in the present study). This data set could be used as an approximate baseline for *E. coli* and *Salmonella* isolation rates in field-harvested animals. In a 1998 excision sampling survey of 1,063 Australian beef carcasses (16), the APC was 3.23 log CFU/cm², the *E. coli* prevalence was 19%, and the *Salmonella* isolation rate was 0.38%. The results from the present study are comparable to those for these beef carcasses. The APC is an indicator of general process hygiene and sanitation, whereas the presence of *E. coli* is an indicator of fecal contamination. Hygienic processing of kangaroo carcasses in the current study was indicated by APCs and *E. coli* counts well within the required bacteriological standards for game meat of 10,000 and 100 CFU/g, respectively (5). *Salmonella* prevalence was similar to that reported in the 1998 beef carcass survey (16). The microbiological quality of kangaroo carcasses appears similar to that of boar and beef carcasses. In subsequent Australian beef carcass surveys (13, 14), significant improvements in beef quality have been noted. However, these studies were not included in our comparison because they did not use the more sensitive excision technique for collecting carcass samples (12).

The high microbiological quality of the kangaroo carcasses examined in this study may be a reflection of the considerable investment made by government and industry in implementation of national quality assurance programs (4) based on the HACCP food safety program as defined by the Codex Alimentarius Commission.

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REFERENCES


