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Prevalence of food-borne pathogens in ready-to-eat meat products in seven different Chinese regions

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ABSTRACT

Microbiological surveillance of ready-to-eat (RTE) meat products provides empirical data to inform scientific guidance for improving food safety. In this study we conducted the first nation-wide survey of food-borne pathogens in RTE meat products in China in 2013. We analyzed the prevalence of food-borne pathogen in different product categories, market distribution, packaged forms, seasonal variation and regions. In total, 4047 samples were collected from all seven regions in China representing distinct geographical areas: Northern, Northeastern, Eastern, Central, Southern, Southwestern, and Northwestern Regions. Samples were collected from catering, retail, and wholesale sources in different seasons throughout the course of the year. The presence of *Listeria monocytogenes*, *Salmonella* spp., *Staphylococcus aureus* and diarrheagenic *Escherichia coli* in all the samples was examined by China's national food safety standard method. All the surveillance data were analyzed according to meat product category, market distribution, packaged form, seasonal variation and regions, respectively. Microbial prevalence of *L. monocytogenes*, *Salmonella* spp., *S. aureus* and diarrheagenic *E. coli* were detected in 1.43% (57/3974), 0.64% (26/4035), 0.79% (32/4047) and 1.06% (40/3774), respectively. The prevalence of heat-treated category RTE meat products was high, probably due to cross contamination. Prevalence data for *Salmonella* spp. and *S. aureus* were higher in the third quarter of the year. We found packaging method played a consistent role in the prevalence of all four food-borne pathogens in packaged ready-to-eat meat products. Bulk ready-to-eat meat products were significantly more likely to contain contamination than portion packaged products. In all, this study implied a potential public health problem. It is necessary to improve control measures of RTE meat products.

1. Introduction

Ready-to-eat meat products are defined as products consisting of or containing meat such as meats in sauce, smoked meat, fried meat, sausage and cooked dried meat. Microbiological surveillance of ready-to-eat (RTE) meat products provides empirical data to inform scientific guidance for improving food safety. Surveillance data may be used to inform the development of food safety standards and define research priorities based on risk assessments. Also it may provide an indication of direct consumer exposure. In recent years, ready-to-eat meat products have exhibited consistently increasing market share in China. From the farm to the consumer, the processing, transportation, and storage of meat products potentially provide growth conditions and nutrient content to support unwanted microbial growth. Because these products do not require additional bactericidal treatment before consumption, the contamination of ready-to-eat meat products by foodborne pathogens continues to draw attention.

Many countries have carried out various investigations on prevalence of food-borne pathogens in meat products. In the report of recalls of food to microbiological contamination classified by US FDA from 2003 to 2011, there were 1395 microbiological recalls which accounted for 42% for the period 1 October 2002 through 30 September 2011 and 1370 microbiological recalls which accounted for 36% for the period 1 October 1993 through 30 September 1998. *Listeria monocytogenes* and *Salmonella* contamination accounted for the greatest number of food products. Microbiological contamination plays an important role in food safety (Dey, Mayo, Saville, Wolyniak, & Klontz, 2013; Wong, Street, Delgado, & Klontz, 2000). *L. monocytogenes* has become a more and more important food-borne pathogen. Most European Union countries reported

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between two and ten reported cases per million in annual reports (Jemmi & Stephan, 2006). *L. monocytogenes* can cause gastrointestinal disorders, septicemia and meningitis, as well as abortion in pregnant women (Latorre et al., 2007). Several investigations in previous surveys have examined *L. monocytogenes* contamination, persistence, and control data across the global food industry. In response to increasing human *Listeriosis* infection trends between 2005 and 2009, a 2010 survey of the prevalence and levels of *L. monocytogenes* in ready-to-eat (RTE) foods were conducted in Sweden. The study compiled survey data from a Swedish national survey and the Swedish component of an EU-wide survey (Lambertz et al., 2012). Separately, a Jordanian investigation examined the prevalence and response to antibiotics of *Salmonella*, *L. monocytogenes*, and *E. coli* O157:H7 in Mediterranean RTE chicken and beef (CB) products sold in Jordanian restaurants (Osaili et al., 2014). In the Republic of Ireland, surveillance data was reported about the occurrence and persistence of *L. monocytogenes* in foods and food processing environments (Leong, Alvarez-Ordonez, & Jordan, 2014). An investigation into the possible source(s) of contamination of ready-to-eat meat products with Listeria spp. and other pathogens in a meat processing plant was conducted in Trinidad (Gibbons, Adesiyun, Seepersadsingh, & Rahaman, 2006). Furthermore, one report provided insight on natural antimicrobial agents and post-slaughter control interventions for the control of *L. monocytogenes* in a ready-to-eat ham product (Lavieri et al., 2014).

There is not enough information about the occurrence of food-borne pathogens in ready-to-eat meat products in China. Accordingly, a nation-wide survey of a range of food-borne pathogens in ready-to-eat meat products was designed for the first time in China in our research. Representing distinct geographical areas, seven regions within China's Northern, Northeastern, Eastern, Central, Southern, Southwestern, and Northwestern Regions participated in the survey.

The present work shows the prevalence of *L. monocytogenes, Salmonella* spp., *Staphylococcus aureus* and diarrheagenic *Escherichia coli* (Nataro & Kaper, 1998) in ready-to-eat meat products in different product categories, market distribution, packaged forms, seasonal variation and regions. The current study was conducted to provide the empirical data needed for risk assessment and development of food safety standards.

2. Materials and methods

2.1. Sample collection

RTE meat products sampled included meat with sauce, smoked meat, fried meat, sausage and cooked dried meat. A total of 4047 samples were sampled from seven regions in 2013. There are 470, 373, 624, 451, 772, 619 and 738 samples from China's Northern, Northeastern, Eastern, Central, Southern, Southwestern, and Northwestern Region. Representative samples were collected from both urban and rural areas with coverage extending to at least half of the counties of each region. In order to account for seasonal variation in microbial growth characteristics, representative samples were collected quarterly throughout the 2013 year with the first quarter covering January to March. The samples were collected from retail, wholesale and catering sources. The sample sets included 2374 meat with sauce samples, 588 smoked meat samples, 85 fried meat samples, 359 sausage samples and 641 cooked dried meat samples. In total there were 756, 1379, 1230 and 682 samples which were collected in the first, second, third and fourth quarter of 2013 respectively. Packaged foods accounted for 1749 of the collected samples and bulk food accounted for 2298 samples.

After purchase from retail or wholesale or catering, ready-to-eat meat products samples were placed in sterile bags and packed in insulated containers. When necessary, samples were packed with ice. Samples were then transported directly to the laboratory for testing within a 24 h period. Date, time, sampling location and manufacturing factory data were recorded. Before being analyzed, the samples were stored at 4 °C. The analysis was done within the expiration period.

2.2. Qualitative and quantitative food-borne pathogens analysis

For each sample, the entire external packaging surface was swabbed with alcohol and sample bags were opened with sterile scissors. The examination of *L. monocytogenes*, *Salmonella* spp., *S. aureus* and diarrheagenic *E. coli* was conducted in accordance with China national food safety standards GB 4789.30–2010(M. O. H. China, 2010a), GB 4789.4–2010(M. O. H. China, 2010b), GB 4789.10–2010(M. O. H. China, 2010) and GB 4789.6–2003(M. O. H. China, 2003), respectively. These samples were inspected by different institutions from different regions. Due to the limitation of technical capability of some institutions, some food-borne pathogens were not detected in some institutions. Based on China national food safety standards GB 29921–2013(N. H. F. P. C. China, 2013), *L. monocytogenes* and *Salmonella* spp. must not be detected in ready-to-eat meat product. In this study, *L. monocytogenes*, *Salmonella* spp. and diarrheagenic *E. coli* were detected qualitatively. *S. aureus* was detected quantitatively. Limits of detection of *S. aureus* is 10 CFU/g. The results showed the prevalence of *L. monocytogenes*, *Salmonella* spp. and diarrheagenic *E. coli*. For *S. aureus*, it showed the rate of samples which were more than 100 CFU/g.

2.3. Statistical analysis

The chi-square test or the Fisher's exact test was used to test for differences. All statistical analysis was performed using SPSS statistical software. The results were considered significant when p value < 0.05.

3. Results

3.1. Prevalence of four food-borne pathogens

Among 3974 samples *L. monocytogenes* tested, 57 (1.43%) samples were positive. Among 4035 samples *Salmonella* spp. tested, 26 (0.64%) samples were positive. Among 4047 samples *S. aureus* tested, 32(0.79%) samples were more than 100 CFU/g. Among 3774 samples diarrheagenic *E. coli* tested, 40 (1.06%) samples were positive.

3.2. Distribution of four food-borne pathogens by product category

Table 1 shows distribution by product category of four food-borne pathogens. Among different product categories, statistical analysis also showed a significant difference ($p < 0.05$) in *L. monocytogenes* and diarrheagenic *E. coli.* The prevalence of *L. monocytogenes* in fried meat was the highest at 2.47% (2/81). The prevalence of diarrheagenic *E. coli* in meat with sauce was the highest at 1.61% (36/2240). There was no significant difference ($p > 0.05$) in *Salmonella* spp. and *S. aureus*.

3.3. Distribution of four food-borne pathogens by market

Fig. 1 and Table 3 show distribution by market of four food-borne pathogens. Among different market distribution, there was no significant difference ($p > 0.05$) in four food-borne pathogens.