Consumer Hygiene Practices Regarding the Use of Home Refrigerators to Store Meat in the Capital Area of Korea

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Abstract

Food hygiene practices must be maintained from farm to table in order to prevent contamination by microorganisms. This study was conducted to investigate consumer hygiene practices related to the refrigerator storage of meat, including a microbial analysis, monitoring of refrigerator temperatures and consumer surveys of female homeowners in the capital area of Korea. Home refrigerator temperatures were maintained above 5°C in 26 (19.7%) of the 132 houses investigated. The percentage of the refrigerators with a total microbial count over 10² CFU/100 cm² was 14.4%. No E. coli, Salmonella spp. or Listeria monocytogenes microbes were detected. However, Staphylococcus aureus was detected in 14 houses (10.6%). The only statistically significant difference in hygiene practices between the non-contamination group and contamination group was in the last time of refrigerator cleaning (p<0.01), as determined by the consumer survey. To improve food hygiene when using a refrigerator, raw materials must be packaged, meat should be stored only on a designated shelf, and cooked foods must be contained to prevent cross-contamination. The refrigerator should be cleaned regularly, at least once a month, and refrigerator thermometers should be monitored below 5°C in order to keep food safe.

Key words: foodborne pathogens, refrigerator, hygiene, temperature, raw-meat storage

Introduction

The demand for meat products is increasing continuously in Korea, due to the increased incomes and corresponding higher dietary expectations of food consumers. However, changes in the global market, the occurrence of BSE (mad cow disease), foot-and-mouth disease, and food poisoning outbreaks related to meat consumption have increased meat safety concerns. These concerns have led consumers to consider the freshness of the meat, its place of origin, its safety, and its taste, rather than its price (Cha, 2007).

Staphylococcus aureus infections originate mainly from humans and livestock. Transmission from employees during the handling of carcasses is considered as the major route of S. aureus contamination (Kim et al., 2009; Kitai et al., 2005). Several previous studies in Korea have examined the contamination of raw meat by various foodborne pathogens, such as Campylobacter spp. in poultry (Kang et al., 2006; Han et al., 2007; Hong et al., 2007), Salmonella spp. in livestock products (Chang, 2000), pathogenic E. coli in rawmeat (Jo et al., 2004; Kim et al., 2006; Lee et al., 2009), Listeria monocytogenes in processed livestock products (Baek et al., 2000; Choi et al., 2001) and S. aureus in animal sources (Moon et al., 2007). Leakage from packages containing rawmeat in the refrigerator presents a risk of contamination of the refrigerator. Therefore, it is necessary to investigate refrigerator hygiene practices and recommend the most appropriate practices for consumers. In this study, we examined refrigerator temperature and the microbial analysis of various foodborne pathogens in the home refrigerators of food consumers in the capital region of Korea; in addition, a consumer survey was used to investigate the home refrigerator hygiene practices of the study participants.

Materials and Methods

Selection of the refrigerators

In the capital area of Korea, 132 homes of consumers who were randomly sampled were visited and swab sam-
samples were collected from the consumers’ refrigerators from January 18 to March 26 in 2010. A cooler with an ice pack was carried to store the swab samples at the appropriate temperature until microbial analysis.

**Refrigerator temperature monitoring**
The storage temperatures of the selected refrigerators were monitored using a data logger (Thermo Recorder Model TR-525, T&D Corporation, Nagano, Japan). The data logger was placed in the raw-meat storage area for 24 h, and the temperature was read at 10 min intervals. The average temperature recorded over 24 h was determined and used for further analyses.

**Sampling for the microbial test**
A 10×10 cm area in the middle of the raw Meat storage area of each refrigerator was swabbed using a 3M E-Swab kit (3M China Ltd., Shanghai, China). The microbial analysis was conducted in the laboratory within 2 h of sample collection.

**Microbial enumeration**
The microbial sample was serially diluted. To quantify the total aerobic count, each diluted 1 mL sample was plated on a plate count agar (PCA, Difco, USA) and incubated at 30°C for 72 h. The diluted 1 mL samples were also plated on 3M Petrifilm (3M) to count coliforms and E. coli. The Petrifilm was incubated at 30°C for 48 h. Blue colonies with bubbles were counted as E. coli, and the red colonies with bubbles were counted as coliforms.

**Standard strains**
*L. monocytogenes* KCCM 40407, *S. aureus* ATCC 12600, and *S. Typhimurium* KCCM 11863 were purchased from the Korea Food Research Institute and the Korea Culture Center for Microorganisms. The microbial examination methods used to compare the isolated colonies are described below.

**Listeria monocytogenes detection**
A 1-mL sample of the swabbed solution was inoculated into 10 mL of UVMListeria selective enrichment broth (modified, Merck, Germany) and incubated at 30°C for 24 h for the 1st enrichment. The enrichment broth was subsequently inoculated into 10 mL of Fraser Listeria selective enrichment broth (Merck) and incubated at 30°C for 24 h for the 2nd enrichment. The enriched culture was streaked onto Listeria selective agar (Oxford formulation, Oxoid, UK) and incubated at 30°C for 48 h. Typical black colonies were inoculated into Tryptic Soy Agar plates (TSA, Difco) and incubated at 30°C for 24 h. The colonies on the TSA were biochemically tested using an API Listeria kit (bioMérieux, France) for final identification.

**Salmonella spp. detection**
A 1-mL diluted swab sample was inoculated into 10 mL of Bacto Peptone Water (BPW, Difco) and incubated at 35°C for 24 h. An enrichment culture sample of 0.1 mL was inoculated into 10 mL of Rappaport-Vassiliadis broth (Difco) and incubated at 42°C for 24 h. The enrichment sample was plated onto Salmonella-Shigella agar (Difco) and incubated at 35°C for 24 h. Typical Salmonella spp. colonies were streaked onto TSA and incubated at 30°C. The colonies on the TSA were identified biochemically with an API 20E kit (bioMérieux).

**Staphylococcus aureus detection**
A 1-mL swab sample was inoculated into 10 mL of Tryptic Soy Broth (TSB, Difco) containing 10% NaCl and incubated at 35°C for 24 h. The enrichment culture was streaked onto Mannitol Salt Agar plates (MSA, Difco) and incubated at 35°C for 24 h. Typical opaque yellow colonies were picked, streaked onto TSA, and incubated at 30°C for 24 h. The colonies on the TSA were tested using an API Staph kit (bioMérieux) for final confirmation.

**Consumer hygiene survey for home refrigerator practices**
The consumers who were selected for refrigerator temperature and microbial analysis (n=132) were also given a survey of consumer hygiene practices related to meat refrigeration. The questions were focused on the cleaning frequency, cleaning method and food storage methods for the home refrigerator.

**Statistical analysis**
The correlation between the microbial contamination level and the hygiene practices of the refrigerator users was analyzed using SPSS WIN 17.0 (SPSS Inc., Chicago, IL, USA); descriptive analyses, ANOVA, χ²-tests, and correlation analyses were conducted.

**Results**
Average temperatures and microbial levels in the raw-meat storage area in the refrigerator
Home refrigerator temperatures were maintained below