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Microbial Contamination in Kitchens and Refrigerators of Korea Households

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ABSTRACT - The objectives of this study were to investigate the microbial contamination level of domestic kitchen environments and to provide information to improve food safety in 50 domestic house kitchens located in Seoul, Incheon, and Gyeonggi-do. Dishcloth, chopping board, and refrigerator swabs were examined for the presence of coliforms, *Salmonella* spp., *Campylobacter jejuni/coli, Escherichia coli*, *Listeria monocytogenes*, and *Staphylococcus aureus*. The means and standard deviations of coliform counts for dishcloths was 4.8 ± 1.84 log CFU/100 g, chopping boards, and refrigerator drawers were 4.04 ± 1.53, 4.11 ± 1.65 log CFU/100 cm^2, respectively. *Salmonella* spp. and *Campylobacter jejuni/coli* were not detected in all samples. *E. coli* were detected in 3 on the dishcloths and 1 of 50 samples in the refrigerator drawer. *Listeria monocytogenes* was detected in the drawer of the refrigerator in 2 of 50 samples. In the case of *Staphylococcus aureus*, the detection on dishcloths, chopping boards, and drawers in refrigerators was 21, 12, and 14 of 50 samples, respectively. The results of microbiological tests of domestic kitchen utensils can be used to emphasize the importance of the sanitary conditions in domestic kitchen environments.

Key words: Domestic kitchen, Sanitary conditions, Dish cloths, Chopping board, Drawer in the refrigerator

Foods that contain pathogenic microorganisms are likely to be handled frequently within the domestic kitchen, and a high proportion of outbreaks of foodborne diseases originated from meals cooked in homes[1)]. Home outbreaks, however, tend to be underreported and factors are poorly understood in comparison with those of restaurant outbreaks. Substantial numbers of consumers frequently implement unsafe food-handling practices[2)]. Many consumers thought home was safer than commercial restaurants[3)]. Restaurants, cafeterias and bars are the most frequently cited locations in which foods implicated in reported foodborne disease outbreaks are consumed. However, it has been reported that illness from foodborne disease arising from foods consumed in private homes is 3 times more frequent than that arising from foods consumed in cafeterias[4)]. The probability of outbreaks in homes was higher than in restaurants[5)]. Unhygienic food handling and low hygiene recognition of housewives in the home can cause food poisoning outbreaks. Actually, the potential risk of food poisoning outbreak that is not reported by epidemiological studies can be very high in the households, which may be one of the primary sources causing food poisoning. Therefore, hygienic food handling in the home is very important for preventing foodborne illness.

In a 2003 report the WHO concluded that about 30% of reported foodborne outbreaks in the WHO European region over the past decade were caused by food consumed in private homes[6)]. In New Zealand, there were 581 reported outbreaks of gastrointestinal disease, involving 7,796 cases during 2011. The most common settings for exposure or transmission were the private home environment (24.8%). Person-to-person transmission was reported for 78.0% of outbreaks in 2011. Foodborne and environmental transmission were reported for 21.0% and 17.7% of outbreaks, respectively. Contamination of food was the most common factor contributing to foodborne outbreaks (40.2%)[7)]. There are statistics that 12~17 percent of general outbreaks of foodborne illness in England and Wales are reported to have originated in the home[8)] while Eves et al. reported in 2006 that figures linking Salmonella and Campylobacter infections to the domestic kitchen are perhaps closer to between 50 and 80 percent[9)].

Home sanitation is closely related with family health. Haysom and Sharp emphasized that the most important time for cleaning in the kitchen is immediately after food has been prepared, with attention focusing on high risk areas such as the work surface, chopping board, taps and other hand contact surfaces[10)]. The refrigerator is used mainly to keep food safe at home, but it has the potential to cause a food poisoning outbreak if it is not managed well. Raising

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the temperature or touching the inside of the refrigerator with contaminated hands can lead to the growth of foodborne bacteria. In addition, foodborne illness may be caused by contamination of kitchen utensils such as dishcloths and chopping boards in the typical housewife's cooking space.

Objectives of this study are to evaluate the microbial contamination level of domestic kitchen environments, specifically in dishcloths, chopping boards, and drawers in the refrigerator in 50 homes located in Seoul, Incheon, and Gyeonggi-do. Such information could be used to establish sanitation guidelines and practices in home kitchens.

Materials and Methods

Sample collection

Fifty homes located Seoul, Incheon, and Gyeonggi-do province were selected to test dishcloths, chopping boards, and drawer in the refrigerator. A total of 150 samples were collected. All samples were immediately placed into Whirl-Pak (Nasco, USA), stored in a cooler containing frozen gel packs to keep samples cool, and transported to the laboratory within 4 h of collection. In each sampled house, a kitchen dishcloth used to clean sink, dinner table was collected. Dishcloths were diluted into 1/10 with sterilized saline in Whirl-Pak and agitated in a stomacher (Seward Stomacher® 400 Circulator, England) for 1 min. Surface samples from chopping boards and drawers in refrigerators were collected by swabbing an area of 100 cm^2 with a sterile cotton swab moistened in saline. Swabs were then placed into tubes containing 100 ml of sterilized saline, and microbiological analyses were performed as described below.

Bacterial isolation

Modifications of methods described in the *Food and Drug Administration Bacteriological Analytical Manual* were used to count coliforms and to isolate *Eshecrichia coli, Salmonella* spp., *Staphylococcus aureus,* and *Listeria monocytogenes, Campylobacter jejuni / coli*[11].

Coliforms

One milliliter samples were inoculated into TEMPO® CC cards and incubated at 35°C for 20~24 h. A Tempo test (Biomerieux, France) is an automated MPN enumeration method. Coliforms in the culture medium resulted in a signal detected by the TEMPO® Reader (based up on fluorescent pH indicator, β-glucuronidase activity).

Escherichia coli

One milliliter samples of the salt rinse solutions were incubated in 9 mL of EC medium at 44.5°C for 24 h for isolation of *E. coli*. The samples were then streaked onto eosin-methylene blue (Difco) agar plates and incubated at 35°C for 24 h. Typical *E. coli* colonies on eosin-methylene blue agar (green and shiny or with dark or purple centers) were subcultured in Nutrient Agar and analyzed by VITEK (Bio-merieux, France).

Listeria monocytogenes

Ten mL in pretreatment solution from each sample was taken in an aseptic manner and 100 ml of UVM were added. Following 24 and 48 h of incubation at 30°C, 0.1 ml of each enrichment culture was plated on Oxford medium containing the Oxford antimicrobic supplement (Difco Laboratories) and incubated at 30°C for 48 h. Three to five suspect colonies with typical *Listeria* morphological characteristics from each plate were characterized on the basis of CAMP test results, beta-hemolysis reaction, catalase reaction, gram staining, and motility through semisolid media.

Salmonella spp.

Ten mL of a rinse solution was mixed with 100 mL of Buffered peptone water (Oxoid) to isolate *Salmonella* spp. After incubation at 35°C for 16~24 h, 1.0 ml of the enrichment broth was transferred into 9.0 ml of tetrathionate broth and Selenite cysteine broth, respectively, and incubated at 42°C and 37°C for 24 h, respectively. Following 24 h of incubation, the broth cultures were streaked onto XLT4 agar plates (Difco), SS agar, Bismuthsulfite, BS agar and incubated for 24 h at 37°C. Presumptive *Salmonella* colonies (3-5) on each plate were selected and used to inoculate triple sugar iron slants (Difco), which were then incubated for 24 h at 37°C. The identities of *Salmonella* isolates were confirmed by using VITEK.

Staphylococcus aureus

Ten mL of each sample were incubated in 100 mL of Tryptic soy broth with 10% NaCl at 35°C for 24 h and streaked to Baird Parker agar (Oxoid, UK) with the addition of 0.01% potassium tellurite (SR0030, Oxoid) and incubated at 35°C for 24~48 h. Typical colonies from both methods were selected for the purpose of obtaining pure colonies on plate count agar (Oxoid, UK). The following tests were carried out: Gram stain, motility, oxidase (Oxoid, UK), lipase, lecithinase and catalase production, tube coagulase (Oxoid, UK) and Staphylase test (Oxoid, UK). The identities of *S. aureus* isolates were confirmed by using VITEK.

Campylobacter jejuni / coli

Ten mL of rinse solution were enriched in modified Bolton broth supplemented only with cefoperazone (33 mg per L), amphotericin B (4 mg per L) and 5% lysed horse

blood for 48 h at 42°C under microaerobic atmosphere (10% CO_2, 5% O_2, and 85% N_2). Enriched broth samples were plated (~0.1 mL) on modified charcoal cefoperazone deoxycholate agar (mCCDA) for isolation and identification of *Campylobacter* spp. Plates were examined after 48 and 72 h. Isolates with gram-negative gull-shaped cells (identified by light microscopy at a magnification of × 1,000), positive reactions in catalase and oxidase tests, and inability to grow under aerobic conditions at 37°C were regarded as *Campylobacter* spp.

Results and Discussion

Coliforms of kitchen utensils from domestic homes

Coliform counts from dishcloths was averaged 4.8 ± 1.84 log CFU/100 g and the range was from non-detected to 7.65 log CFU/100 g. Drawers in refrigerators, and chopping boards were averaged, 4.11 ± 1.65 and 4.04 ± 1.53 log CFU/100 cm^2, and the range was from non-detected to 6.32 and 5.2 log CFU/100 cm^2, respectively. Coliforms on dishcloths were detected in 94% of households in the study (47 of 50). The detection rates of coliforms at drawers in refrigerators and chopping boards were 96.0% (48 of 50), and 90.0% (45 of 50), respectively (Table 1). The existence of the coliforms has been considered as an indication that the product was unhygienic conditions. Coliform counts should be less than 10 CFU/100 cm^2 in kitchen apparatus[12]. In this study, most of the utensils in the household kitchens were risky because of higher coliform counts. Coliform counts on chopping boards and in refrigerators in kitchens detected for 10 samples were 1.3 and 1.7 log CFU/cm^2, respectively[13]. On kitchen surfaces, coliform counts ranged from 1.3 log CFU/cm^2 (microwave) to 1.7 log CFU/cm^2 (sink). The above results were different from those of our study in Korean household kitchens because the Korean cookery environment is different from Irish cookery environment[13]. Coliform counts in the Korean household kitchens were higher than those on Ireland[13]. According to the results on coliform counts, the hygienic conditions in Korean domestic kitchens were insufficient compared with foreign kitchens.

Foodborne bacteria

Table 2 showed that the isolates of pathogenic bacteria from kitchen utensils. *E. coli* were detected on 2.6%, 3 samples in dishcloths and 1 sample in the refrigerator drawer out of 50 samples of each. In the case of *S. aureus*, the detection on dishcloths, chopping boards, and drawers in refrigerators was 21, 12, and 14 samples out of 50 samples, respectively. In *S. aureus* detection, refrigerator, sink, and dishcloths were detected in high level at 30% in chopping boards and 10% in microwaves, and *E. coli* was detected in 10% at refrigerator, sink, and dishcloths, respectively[13]. Kennedy et al. reported that *S. aureus* detection rates of kitchen utensils was 36.7%, *E. coli* was 5%, *Salmonella* spp. was 1.7%. However, *Campylobacter jejuni/coli*, *Y. enterocolitica*, and *E. coli O157:H7* were undetected in any sample[13]. According to Kennedy et al. study, analysis of swab samples also detected the incidence of *S. aureus* (41%), *E. coli* (6%), *Salmonella enterica* (7%), *L. monocytogenes* (6%), and *Y. enterocolitica* (2%), but *C. jejuni* and *E. coli O157:H7* were undetected in domestic refrigerators[13].

L. monocytogenes was detected only in the drawer of the refrigerator in 2 of 50 samples isolated in 1.2% of the refrigerators in this study (Table 2), in agreement with previous reports of *L. monocytogenes* between 0% and 2.9% in refrigerators[14,15]. Being a psychotropic organism, *L. monocytogenes* is capable of growth at refrigeration temperatures, which means that low numbers of initially contaminating cells may proliferate and become hazardous if present on or transferred to ready-to-eat foods. *L. monocytogenes* also can adhere to many kinds of surfaces including stainless steel, glass, and rubber[16]. The presence of *L. monocytogenes* in domestic refrigerators is significant as a public health concern as it is capable of contaminating foods and is able to persist on dry surfaces and to grow at refrigeration temperatures. *Campylobacter* spp., *Salmonella* spp., and *E.*

Table 1. Occurrence and coliforms counts in the 50 domestic kitchens (mean ± SD)

Samples	Positive no. n = 50 (%)	Total coliforms
Dish cloths	47 (94.0)	4.8 ± 1.84 (log CFU/g)
Drawer in the refrigerator	48 (96.0)	4.11 ± 1.65 (log CFU/100 cm^2)
Chopping board	45 (90.0)	4.04 ± 1.53 (log CFU/100 cm^2)

Table 2. Percentage and isolated number of foodborne pathogens on swab samples of kitchen utensils in the 50 domestic kitchens

Samples	No. of Isolates n = 50 (%)				
	Escherichia coli	*Staphylococcus aureus*	*Salmonella spp.*	*Listeria monocytogenes*	*Campylobcter jejuni/coli*
Dishcloths	3 (6.0)	21 (42.0)	0 (0.0)	0 (0.0)	0 (0.0)
Chopping board	0 (0.0)	12 (24.0)	0 (0.0)	0 (0.0)	0 (0.0)
Drawer in the refrigerator	1 (2.0)	14 (28.0)	0 (0.0)	2 (4.0)	0 (0.0)

coli O157:H7 were not recovered from any refrigerators in this study. However, a number of significant foodborne pathogens are found on the inside of household refrigerators according to Jackson et al.; *S. aureus* was recovered from 6.4%, *L. monocytogenes* and *E. coli* from 1.2% and *Y. enterocolitica* from 0.6% of examined refrigerators[17]. Scott et al. emphasized the potential hazard associated with dishcloths, cleaning cloths, and other wet cleaning utensils[18]; unless cloths are thoroughly dried after use, an effective decontamination procedure before, rather than after use, is required to ensure that cloths do not act as reservoirs and disseminators of contamination in the kitchen, bathroom and toilet[19]. Alternatively, the use of disposable cloths and paper towels is suggested. Doyle et al. suggested that consumers have to sanitize and wash regularly when they used the dishcloths[20]. Sixty-four percent of consumers cut vegetables without sanitation and washing after cutting raw meat. Weingold et al. suggested that the chopping board has been important factor in domestic kitchen sanitation[21]. The FDA has tried to educate people that foodborne bacteria are invisible and can spread through the kitchen utensils such as cutting boards, utensils, sponges, and countertops[22].

Correlation between *S. aureus* and coliforms in dishcloths and refrigerator drawers

Dishcloths and refrigerator drawers with higher coliform counts are more likely to be contaminated with *S. aureus*. Household dishcloths contaminated by *S. aureus* had mostly high coliform counts above 3.0 log CFU/100 cm^2 (Fig. 1). Moreover, Fig. 2 shows that refrigerator drawers with concentrations in coliforms higher than 3 log CFU/100 cm^2 are more likely to be contaminated with *S. aureus*. Experimental studies suggest that the conditions necessary for foodborne transmission to occur can be found in Korean domestic kitchens. It is widely assumed that Increment of coliforms might be increased probability of contamination by *S. aureus* in the domestic kitchen. Lots contamination of coliforms, sanitary indicative bacteria, says that the probability of food poisoning bacteria such as intestinal bacteria may be high. The results in present study showed that a high detection rate of coliforms was followed by *S. aureus*. Specially, Efstratiou et al. showed that the results are correlated between coliforms and *S. aureus* each other in sea water[23]. Also, the possibility of contamination by *E. coli* might rise as the number of coliforms rises[24]. *S. aureus* and *E. coli* has been associated with food borne illnesses and even the deaths of many people each year[25]. In many countries, food poisoning caused by *Staphylococcus* spp. has been ranked second or third causative agent often associated with food borne disease outbreaks[26]. Contamination may result from handling cooked food with contaminated hands, equipment

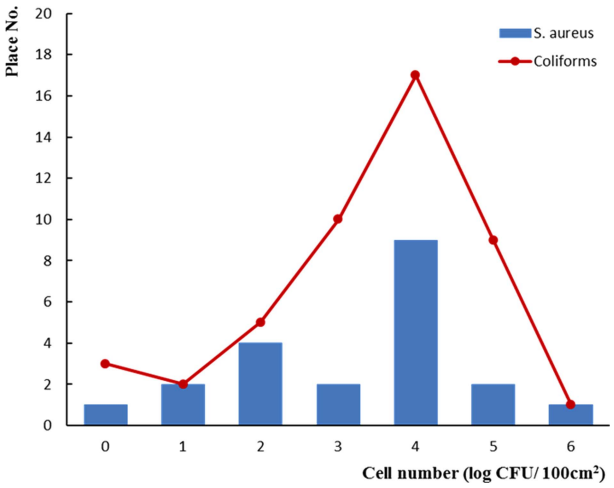

Fig. 1. The correlation between *Staphylococcus aureus* and coliforms in dishcloths at domestic households.

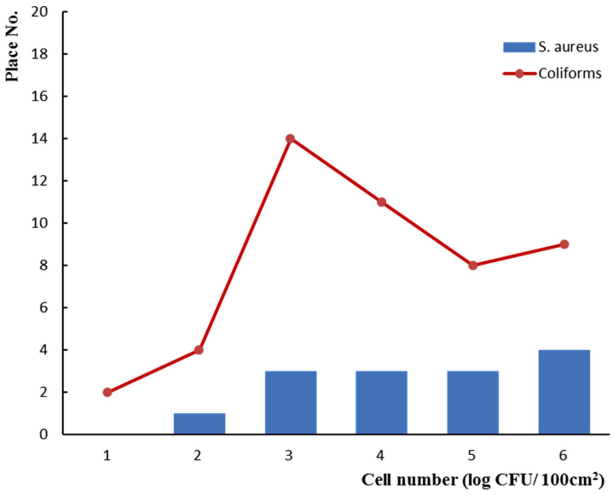

Fig. 2. The correlation between *Staphylococcus aureus* and coliforms in refrigerator drawers at domestic households.

or utensils[27]. *E. coli* and *S. aureus* are amongst the most common pathogens found on hands[19]. Human hands are in regular contact with the surrounding environment and a variety of pathogens can reach the mucous membranes in the mouth, nose, eyes and genitals of human being through the hands and consequently contribute to foodborne illness outbreaks[28]. Food can become contaminated via dirty hands if there is a lack of proper hand hygiene among the food handlers when handling food[24]. Home kitchens are particularly vulnerable to unsafe food-handling practices, as they do not have the benefit of tight food safety monitoring systems similar to commercial food facilities[29]. Poor hand hygiene may contribute to high levels of *S. aureus* and *E. coli* on the hands of food handlers as verified in the finding of Ayçiçek et al.[30]. Hence, good hand hygiene practices should be practiced all the time, not just in the kitchen.

Food handler's hygiene practices in the domestic kitchen should be taken to ensure that the outbreaks of foodborne illnesses can be minimized. Contaminants to domestic kitchens may survive and proliferate in dirt and food debris. Contaminants may then grow potentially reaching infectious dose levels and, in the presence of moisture and food debris, surviving to contaminate the next food preparation event[31]. The source of these contaminants is varied because domestic kitchens are used for a wide range of activities. The role of effective cleaning is important in preventing these activities from contributing to domestic outbreaks of gastrointestinal illness[2]. Contamination rate of coliform or S. aureus in dishcloth was higher than in the refrigerator or cutting boards as a result. Because the dishcloths are unsanitary compared to other utensils in kitchen, it makes sense to use a disposable paper towel or to be disinfected by using a heat and sanitizer periodically. A refrigerator is also required to sterilize regularly because it is very vulnerable hygienically. Above all, education about food hygiene will have to be made essentially for housewives. Further studies are needed to help to plan targeted cleaning which concentrates on riskier places spreading bacterial contamination around the domestic kitchen.

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국문요약

본 연구는 경기도, 인천 및 서울 지역에 있는 50 곳의 가정 내 주방을 대상으로 미생물학적 오염 정도에 대해 조사하여 가정 내 주방 위생 관리 실태를 평가하고자 하였다. 행주, 냉장고 칸, 도마의 대장균군과 다양한 병원성 미생물의 존재 여부에 대한 실험을 실시하였다. 주방기구의 대장균군을 분석한 결과, 행주는 4.8 ± 1.84 log CFU/100 g, 검출률 94.0% (50건 중 47건)의 값을 나타내었고, 냉장고 칸은 4.11 ± 1.65 log CFU/100 cm^2, 검출률 96% (50건 중 48건), 도마는 4.04 ± 1.53 log CFU/100 cm^2, 검출률 90.0% (50건 중 45건)로 나타났다. 병원성 세균의 오염 실태를 조사한 결과, *E. coli*는 행주에서 6.0%, 냉장고 칸에서 2.0%의 검출률을 보였으며, *Listeria monocytogenes* 같은 경우에는 냉장고 칸에서 4.0%의 검출률을 보였다. *Salmonella* spp.과 *Campylobacter jejuni*의 경우에는 모든 시료에서 검출되지 않았으나 *Staphylococcus aureus*의 경우에는 행주, 도마, 냉장고 칸에서 각각 42.0%, 24.0%, 28.0%로 모두 높은 검출률을 보여 위생관리 소홀의 심각성을 나타내었다. 가정 내 주방용품 및 기구의 미생물학적 분석 결과 전반적으로 위생상태가 불량한 것으로 평가되었으며 행주 및 도마, 냉장고 칸에서 위생지표세균인 대장균군과 병원성 세균인 황색포도상 구균의 높은 검출률을 보여 가정 내 주방의 위생관리가 잘 되고 있지 않음을 시사하였다. 본 연구를 통해 가정 내 주방에서의 위생 관리와 사용실태에 대한 인식이 변화되어 가정에서도 위생 관리의 중요성이 강조되어야 할 것이다.

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