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The Microbiological Safety Evaluation of Foodservice Facilities and Side Dishes in Elementary Schools and Universities in the Jeolla-do Region

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Abstract The microbiological safety of foodservice facilities and side dishes in 6 elementary schools and 6 universities in the Jeolla-do region was evaluated. The micro-aerosol evaluation of foodservice facilities including the kitchen, refrigerators, and freezers showed a comparatively high level of microbial contamination. In the microbial safety evaluation of cooking utensils and appliances, the total plate counts of serving tables, cutting boards, and food plates were comparatively high, but did not reveal significant counts of coliforms, *Staphylococcus aureus*, and *Escherichia coli* were both below the general limit of microbial contamination. The microbiological safety of the cooking utensils and appliances were satisfactory. In the microbiological safety evaluation of side dishes served at these foodservice facilities, microbial counts were generally below the limit of microbial contamination.

Key words: microbiological safety, foodservice facilities, side dishes, elementary school foodservice, university foodservice

Introduction

In recent years, there have been changes in the dietary habits of society where people eat more frequently in commercial and institutional foodservice outlets in schools and in the workplace. Therefore, the importance of the foodservice industry and its influence on people's health is increasing (1, 13). The Seoul Catering Service Inc. was the first company to start a foodservice program for their employees in South Korea in 1988. There has been a radical increase in the engagement of foodservices by small and large enterprises. Foodservice expenses have doubled from 2 trillion to 4 trillion won. Reflecting the corporate desire to maximize management efficiency, after the IMF of 1998, foodservices have been introduced in many companies. Among these services, some are self-managed, costing some 2.3 trillion yuan or 59.4% of the total foodservice expenditure in Korea while others are managed by consignment, costing 1.6 trillion yuan or 40.6 % of the total expenditure (2).

A survey conducted by the Korean Food and Drug Administration (KFDA) (3) found that the foodservice market is expanding at a 10% rate increase per year; from 11,464 services in 1998 to 18,431 in 2002. Specialized consignment foodservice companies, which were developed by corporations in the 1990s', are growing at a rapid speed in their service of companies, hospitals, factories, and colleges.

Regardless of this rapid increase of group foodservices, sanitation management skills typically do not keep up with corporate growth and are often executed without scientific and systematic consideration (4, 12). Notably, small individual services and employee dining areas have poor quality sanitation management. This characteristic is usually attributed to the desire to maximize profits by using cheaper ingredients and facilities. Food poisoning incidents are increasing every year, indicative of the poor sanitary management. Food poisoning incidents are happening primarily at an institutional level than at the home level, therefore victims of these accidents are increasing. Even though the frequency of food poisoning incidents has decreased, the number of victims has increased: 199 incidents and 4,577 victims in 1998, 174 incidents and 7,764 victims in 1999, 104 incidents and 7,269 victims in 2000, and 93 incidents and 6,406 victims in 2001 (3). The typical reasons for these food poisoning incidents include: unacceptable temperatures for food storage, inappropriate cooking methods, low quality of human, and environmental sanitary management, unsafe ingredients, contaminated facilities, and a shortage of education and supervision regarding cross contamination.

This study evaluated the microbial safety of foodservice facilities and side dishes provided by elementary schools and colleges in the Jeolla-do area. It will provide important information that can be used to develop an efficient system for food safety in foodservice industry.

Materials and Methods

Sampling the foodservice sites This study sampled a total of 12 school foodservice facilities, which consisted of 6 elementary schools and 6 universities in Jeolla-do region, in order to evaluate microbial food safety. Microbiological safety analysis was conducted for two months from June 2004 to August 2004. The foodservice facilities were chosen based on the size of facilities, service level,

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and the number of customers. It included 2 elementary schools and one university with 300 customers per lunch per day, 4 elementary schools with 1,000 lunch customers, 3 universities with 1,500 lunch customers and one university with 2,000 lunch customers.

Food sampling method and pre-treatment Researchers collected different kinds of food served for a day in order to evaluate microbiological safety: 2 kinds of food from Jeonbuk A elementary, one from Jeonbuk B elementary, one from each Jeonnam C and D elementary, two kinds of food from Gwangju E elementary, and 3 kinds of food from Gwangju F university. Two kinds of food from Jeonbuk A and B university, 2 kinds of food from Jeonnam C and D universities, 2 kinds of food from Gwangju E university, and 3 kinds of food from Gwangju F university. There were no similar kinds of food that were collected.

In order to prevent cross contamination, foods were collected in sanitized plastic bags, kept in a cooler, and carried to the laboratories as fast as possible. The collected foods were treated aseptically and inspected using aseptic instruments. The solid-type foods were mixed with 225 mL of 0.85%(w/v) sodium chloride (Difco Laboratories, Detroit, MI, USA) and homogenized by a stomacher (BagMixer®400; Intersicence Inc., St. Norm, France). Only 1 mL of the homogenized food was used for further experiment. Liquid-type foods were homogenized using a vortex mixer (Maxi Mix II Mixer; Barnstead International, Dubuque, IA, USA) and were diluted with 0.85%(w/v) sodium chloride using a stomacher (BagMixer®400; Intersicence Inc.) prior to microbiological tests.

Knives, cutting boards, and serving plates were chosen in order to evaluate the microbial safety of the cooking utensils. Researchers wiped the surface of the cooking utensils and serving plates over a 5×5 cm area using sanitized cotton swabs in a test tube with 10 mL of 0.85% (w/v) sodium chloride (Difco). The swabs were placed in test tubes and vortex-mixed (Maxi Mix II Mixer, Barnstead International) to make a suspension of the sample.

In a prior study, Park *et al.* (5), sampled their suspension over a 10×10 cm area however, the samples for this study were over a 5×5 cm area because of the small size of utensils. The results were multiplied by 4 so it could be parallel to the results from the size of 10×10 cm.

Methods for microbial analysis In order to evaluate the microbiological safety of microaerosol (total count, coliform group, and fungi), plates with 15 mL of plate count agar (Difco), deoxycholate lactose agar (Difco), and potato dextrose agar (Difco) were placed in the sampling place with the lid opened. They were then were incubated for 24-48 hr at 35±1°C and then for 48 hr at 35±1°C. The incubation of the plates was extended for 5 days at 30°C.

The conventional plate count method was performed for aerobic plate counting, using plate count agar (Difco) and for coliform bacteria using deoxycholate lactose agar (Difco). After preparing all decimal dilutions with 0.85% (w/v) sodium chloride, 15 mL plate count agar or deoxycholate lactose agar (cooled to 43-45°C) was mixed with the sample dilutions in each plate and incubated for 24-48 hr at 35±1°C. A coliform test was performed by a 5-tube most probable number (MPN) series of EC Broth (Difco) and incubated for 24±2 hr at 44.5±0.2°C for gas production (6). For enrichment of *Staphylococcus aureus,* in the sample, 1 mL of each decimal dilution was added to trypticase soy broth (Difco) with 10% NaCl (Difco) and incubated for 16 hr at 35-37°C. The enriched broth was plated on mannitol salt agar (Difco) with egg-yolk and incubated for 24 hr at 37°C. After isolating the typical *S. aureus* appearance on mannitol salt agar with egg yolk agar (MSA), suspect colonies were tested for the confirmation of *S. aureus* using Gram staining and coagulase test (6).

Statistical analysis All experiments and measurements were performed in duplicate and the results were expressed as the mean±standard deviation. The data obtained were statistically analyzed by the SPSS program version 12. The comparison of means was done using Duncan's multiple range tests at a level of 0.05.

Results and Discussion

Evaluation of food safety through measuring microaerosol at the foodservice facilities The numbers of microaerosol pathogens, that is, the total plate counts, coliform groups, and fungi, were measured at the 12 targeted foodservice facilities in order to evaluate the level of food safety (Table 1 and 2). The foodservice facilities were investigated largely in two areas; the foodservice area and the cooking area. The foodservice area included 2 dining tables and 2 serving tables. The cooking area included 4 working tables (a cooking board, a spice shelf, a cooking preparation table, and a washing area), refrigerators, and freezers. Table 1 shows the results from the microaerosol tests conducted at 6 elementary schools. The total plate counts were 2.56 (CFU/5 min/plate) for dining tables, 3.30 for serving tables, 2.94 for working tables, 2.00 for refrigerators, and 2.89 for freezers. The coliform levels were 1.60 (CFU/5 min/plate) for dining tables, 1.67 for serving tables, 2.10 for working tables, 1.00 for refrigerators, and 2.37 for freezers. Finally, fungi were found at levels of 4.40 (CFU/5 min/plate) for dining tables, 3.00 for serving tables, 7.93 for working tables, 3.19 for refrigerators, and 9.13 for freezers. The pathogen numbers were pretty low with levels below 4.40 CFU/5 min/plate for all tested areas, except the numbers of fungi of 7.93 for the working tables and 9.13 for the freezers

Table 1. Microaerosol counts at the group foodservice areas and kitchens of 6 elementary schools (CFU/5 min/plate)

	Total plate count	Coliforms	Fungi
Dining table	2.56±1.10$^{b1)}$	1.60±0.89^{b}	4.40±4.90^{b}
Serving table	3.30±3.40^{d}	1.67±1.03^{b}	3.00±2.60^{a}
Working table	2.94±2.70^{c}	2.10±2.23^{c}	7.93±9.60^{c}
Refrigerator	2.00±0.00^{a}	1.00±0.00^{a}	3.19±1.48^{a}
Freezer	2.89±1.20^{c}	2.37±2.89^{c}	9.13±5.07^{d}

[1)]Mean±SD, [a-d]: values with different superscripts with columns are significantly different by Duncan's multiple range test at $p<0.05$.

(Table 1).

The results from the microaerosol tests conducted at 6 universities are shown in Table 2. The numbers of general bacteria varied between tested areas while the working tables showed the highest levels of bacteria: 5.00 (CFU/5 min/plate) for dining tables, 5.34 for serving tables, 6.95 for working tables, 2.56 for refrigerators, and 3.48 for freezers. Coliforms were found at levels of 4.11 (CFU/5 min/plate) for dining tables, 5.11 for serving tables, 6.53 for working tables, 1.80 for refrigerators, and 2.50 for freezers. Finally, fungi were found at levels of 4.40 (CFU/5 min/plate) for dining tables, 4.20 for serving tables, 9.10 for working tables, 10.06 for refrigerators, and 3.96 for freezers. Total plate counts were mainly found on working tables, coliforms were predominantly found on working tables and on serving tables and fungi were primarily found in refrigerators. Fungi showed the highest numbers (i.e., 9.10 and 10.03 CFU/5 min/plate on working tables and refrigerators, respectively) more than any other microaerosol (Table 2). In summary, total plate counts and coliforms were mostly found on working tables and fungi were mostly found in refrigerators and freezers. The result of this study showed that the level of total plate counts was low, with numbers below 5 CFU/5 min/plate, except for working tables (6.95 CFU/5 min/plate). Bae and Chun study (7) also showed the number of total plate count below 6 CFU/5 min/plate. A high level of microaerosols indicates poor hygiene conditions including air pollution of the cooking area. Airborne microorganisms are caused by poor ventilation, dirty washing areas, drain outlets, poor hygiene of cooks, floor and appliance using high-pressure water hoses, and dust carried by food from storage (8). Kang (9) suggested a hygienic working environment, which has a layout separating contaminated and non-contaminated areas considering the flow of air in the foodservice facilities and appropriate building materials in order to reduce or eliminate airborne microorganisms.

Since most of the airborne microorganisms are originated from an unsanitary or unhygienic environment, it is useless to clean only the air without improving the other unsanitary conditions. The number of microorganisms' increases when the cooks lack proper hygiene, wear dirty clothes, talks, breathes, coughs, or sneezes. Cooks require frequent hand-washing before and during work and after coming back from work breaks. In addition, wearing clean clothes, hats, gloves, and keeping their hair and nails clean are essential.

Table 2. Microaerosol counts at the group foodservice areas and kitchens of 6 universities (CFU/5 min/plate)

	Total plate count	Coliforms	Fungi
Dining table	5.00±3.27$^{c1)}$	4.11±2.62^{c}	4.40±3.60^{a}
Serving table	5.34±2.92^{c}	5.11±2.89^{c}	4.20±2.74^{a}
Working table	6.95±4.74^{d}	6.53±5.90^{d}	9.10±7.94^{b}
Refrigerator	2.56±1.30^{a}	1.81±2.17^{a}	10.06±9.20^{b}
Freezer	3.48±1.14^{b}	2.50±1.20^{b}	3.96±4.15^{a}

[1)]Mean±SD, [a-d]: values with different superscripts with columns are significantly different by Duncan's multiple range test at $p<0.05$.

Evaluation of hygiene condition of cooking utensils and appliances using Swabbing method The hygienic conditions of cooking utensils and appliances in 6 elementary schools and 6 universities was evaluated using a swabbing method. The total plate counts and the numbers of *S. aureus*, and *Escherichia coli* were investigated. For elementary schools, the total plate counts were detected at levels of 32.00 (CFU/25 cm^2) for dining tables, 56.65 for serving tables, 63.50 for knives, 114.00 for cutting boards, 22.00 for personal trays, and 120.00 for floors (Table 3). Coliforms were detected at levels of 2.00 (CFU/25 cm^2) for dining tables, 7.00 for serving tables, 3.67 for knives, 4.00 for cutting boards, 5.50 for personal trays, and 5.00 for floors. *S. aureus* was found at levels of (1.50 CFU/25 cm^2) for dining tables, 1.80 for serving tables, 1.00 for knives, 1.33 for cutting boards, 2.00 for personal trays, and 2.50 for floors. *E. coli* was not detected on any utensils or appliances.

By comparison, the results of the evaluation conducted at the 6 universities showed that the level of total plate counts was 13.20 (CFU/25 cm^2) for dining tables, 84.33 for serving tables, 4.00 for knives, 21.60 for cutting boards, and 106.00 for personal trays as shown in Table 4. *S. aureus* was detected at levels of 1.00 (CFU/25 cm^2) for dining tables, 4.50 for serving tables, 1.67 for knives, 1.00 for cutting boards, and 2.00 for personal trays. *E. coli* was not detected from any utensils or appliances. Harrigan and McCance (10) developed guidelines for 'safe' levels of microorganisms in the foodservice environment: under 125 (CFU/ 25 cm^2) for total plate counts, under 10 for

Table 3. Microbial quality evaluation of cooking utensils and appliances of 6 elementary schools using swabbing method (CFU/25 cm^2)

	Total plate count	Coliforms	*S. aureus*	*E. coil*
Dining table	32.00±0.00$^{b1)}$	2.00±0.00^{a}	1.50±0.71^{a}	ND$^{2)}$
Serving table	56.67±30.66^{c}	7.00±4.24^{c}	1.80±1.30^{a}	ND
Knife	63.50±40.31^{c}	3.67±0.58^{b}	1.00±0.00^{a}	ND
Cutting board	114.00±76.37^{b}	4.00±0.00^{c}	1.33±0.58^{a}	ND
Personal tray	22.00±0.00^{a}	5.50±3.54^{d}	2.00±1.22^{b}	ND
Floor	120.00±0.00^{b}	5.00±4.24^{d}	2.50±2.12^{b}	ND

[1)]Mean±SD, [a-e]: values with different superscripts with columns are significantly different by Duncan's multiple range test at $p<0.05$.
[2)]ND: Not detected.

Table 4. Microbial quality evaluation of cooking utensils and appliances of 6 universities using swabbing method (CFU/25 cm^2)

	Total plate count	Coliforms	*S. aureus*	*E. coil*
Dining table	13.20± 4.04$^{b1)}$	8.00±5.65^{c}	1.00±0.00^{a}	ND$^{2)}$
Serving table	84.33±69.40^{c}	2.00±0.00^{a}	4.50±3.51^{c}	ND
Knife	4.00±3.00^{a}	2.25±1.89^{a}	1.67±1.15^{a}	ND
Cutting board	21.60±45.25^{b}	3.50±3.00^{b}	1.00±0.00^{a}	ND
Personal tray	106.00±19.80^{c}	7.00±1.73^{c}	2.00±0.00^{b}	ND

[1)]Mean±SD, [a-e]: values with different superscripts with columns are significantly different by Duncan's multiple range test at $p<0.05$.
[2)]ND: Not detected.

coliform, under 20 CFU for *S. aureus*. Therefore, we concluded that the hygienic condition of cooking utensils and appliances of elementary schools and universities were at a satisfactory level.

Evaluation of hygiene condition of side dishes Table 5 and 6 show the results from assessment of hygiene conditions of side dishes from 6 elementary schools and 6 universities. Evaluation of the foods provided for the day demonstrated that the total plate counts were at the level of 8.0×10^3 (CFU/g) for *yeolmoo kimchi*, 2.5×10^5 for *mu-cheji*, 1.0×10^3 for *sausage-bokkum*, 3.0×10^3 for *gogumadae-namool*, 1.0×10^2 for *cabbage kimchi*, and 1.1×10^3 for *saewoo-bokkum*. Total plate counts were not detected in *chui-namool* and *bulgogi*. Coliform were found at levels of 7.5×10^2 CFU/g for *mu-cheji*, and 4.0×10^2 for *gogumadae-namool*. Coliforms were not detected in other foods. *S. aureus* and *E. coli* were not detected in any of the targeted foods (Table 5).

For universities, the total plate counts were at levels of 1.0×10^2 (CFU/g) for *jabchae*, 2.0×10^3 for *oi-kimchi*, 2.0×10^2 for *kongnamul*, 1.0×10^3 for *godeunge-zorim*, 3.0×10^2 for *cabbage kimchi*, 1.2×10^3, for *yachae-tuigim*, 6.0×10^3, *mu-cheji*, 3.2×10 for *nogdu-namool*, 1.0×10^3 for *jangzorim*, 1.0×10^3 for *aehobag-bokkum*, 1.0×10^4 for *dubu-jeon*, and 2.0×10^3 for *gaji-namool*. Total plate counts were not found in *buchu-namool*. Coliforms were found at the level of 2.6×10^2 CFU/g for *kongnamul*, 7.0×10^2 for *godeunge-zorim*, 8.0×10^2 for *aehobag-bokkum*, and 2.8×10^2 for *gaji-namool*. Coliforms were not found in other foods. *S. aureus* and *E. coli* were not detected in any side dishes (Table 6). Since the Korean Food Code has not provided safety guidelines for total plate counts, so we used Solberg *et al.* (11) criteria for food microorganism levels. They suggested that, for raw ingredients, the numbers for total plate counts should be below 10^2-10^5 CFU/g, the number of coliforms should be below 10^2-10^4, and *S. aureus* and *E. coli* should not be found. In the case of cooked food, the number of total plate count should be below 10^5, the number of coliforms should be below 10^2 CFU/g. According to the criteria, the foods that were investigated from the targeted school sites are all at satisfactory levels with respect to microbiological safety.

This study evaluated the safety level of foodservice provided in elementary schools and universities in the Jeolla-do area. Foodservice and the side dishes prepared

Table 5. Microbial quality evaluation of side dishes serviced at 6 elementary schools (CFU/g)

	Total plate count	Coliforms	*S. aureus*	*E. coil*
Yeolmoo kimchi (young radish *kimchi*)	8.0×10^3	ND[1)]	ND	ND
Chui-namool (blanched and seasoned *Saussurea* sprouts)	ND	ND	ND	ND
Mu-chaeji (shredded radish *kimchi*)	2.5×10^5	7.5×10^2	ND	ND
Sausage-bokkum (pan-fried sausage)	1.0×10^3	ND	ND	ND
Gogumadae-namool (blanched sweet potato stem saussurea sprouts)	3.0×10^3	4.0×10^2	ND	ND
Kimchi (Chinese cabbage *kimchi*)	1.0×10^2	ND	ND	ND
Bulgogi (seasoned & cooked beef)	ND	ND	ND	ND
Saewoo-bokkum (roasted dry shrimp)	1.1×10^3	ND	ND	ND

[1)]ND: Not detected.

Table 6. Microbial quality evaluation of side dishes serviced at 6 universities (CFU/g)

	Total plate count	Coliforms	*S. aureus*	*E. coil*
Jabchae (seasoned sweet potato starch noodle)	1.0×10^2	ND[1)]	ND	ND
Oi-kimchi (cucumber *kimchi*)	2.0×10^3	ND	ND	ND
Kongnamul (blanched & seasoned soybean sprouts)	2.0×10^2	2.6×10^2	ND	ND
Godeungeo-zorim (seasoned & boiled mackerel)	1.0×10^3	7.0×10^2	ND	ND
Kimchi (Chinese cabbage *kimchi*)	3.0×10^2	ND	ND	ND
Yachae-tuigim (fried vegetables)	1.2×10^3	ND	ND	ND
Mu-cheji (shredded radish *kimchi*)	6.0×10^3	ND	ND	ND
Nogdu-namool (blanched & seasoned mung-bean sprouts)	3.2×10	ND	ND	ND
Jangzorim (hard-boiled beef in soy sauce	1.0×10^3	ND	ND	ND
Aehobag-bokkum (pan-fried zucchini)	1.0×10^3	8.0×10^2	ND	ND
Dubu-jeon (pan-fried tofu)	1.0×10^4	ND	ND	ND
Gaji-namool (blanched & seasoned eggplant)	2.0×10^3	2.8×10^2	ND	ND
Buchu-namool (blanched & seasoned Korean leek sprouts)	ND	ND	ND	ND

[1)]ND: Not detected.

and served at the school cafeterias were assessed as to their safety level. Evaluation of airborne microorganisms showed that the level of microorganisms found on work tables, and in refrigerators and freezers were high. The microbiological contamination was above the allowable standard for these locations. The measurement of microbiological safety on the surfaces of cooking utensils and plates showed that total plate counts of serving tables, cutting boards, and personal trays were relatively high but not at a significant level. Coliforms, *S. aureus*, and *E. coli* were below the levels being considered as hazardous. In addition, microbiological safety evaluations for the side dishes that were served in these facilities showed that they all were below allowable levels of food contamination.

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