Artikel Asli/*Original Article*

Microbiological Assessment of Food Contact Surfaces in Residential College Cafeterias at a Local University in Malaysia

(Penilaian Tahap Pencemaran Mikrobiologi pada Permukaan Sentuhan Makanan di Kafeteria Kolej Kediaman di Sebuah Universiti Awam di Malaysia)

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ABSTRACT

A food premise's sanitation level can be reflected by the cleanliness of its food contact surfaces. Contaminated food contact surfaces along with poor handling methods by food handlers may increase the risk of foodborne diseases through cross-contamination events. This study aimed to assess the microbiological contamination levels on food contact surfaces of 12 residential college cafeterias in a local university and its correlation with the cafeteria's premise grade. The presence of selected indicator and pathogenic microorganisms (total viable count (TVC), total coliform, Escherichia coli, Staphylococcus aureus, Salmonella spp., and Shigella spp.) on food contact surfaces were also determined. Cutting boards, knives and utensils (cutleries, bowls and plates) that were used for ready-to-eat food were sampled for this study. The cafeteria's premise grade was obtained based on the food premise inspection report by the university Health Centre. Three cafeterias have significantly higher (p < 0.05) bacterial counts (TVC) as compared to the international standard (1 log CFU/cm^2). E. coli was only found in 2 cafeterias while Salmonella spp. was only detected on 7 of the cafeterias. Cutting boards were identified as the most contaminated food contact surface whereas utensils were the least contaminated. There was only a weak correlation between the microbiological levels on food contact surfaces and the cafeteria's inspection grade (r = 0.02 p > 0.01). This study demonstrated that the sanitation level of food contact surfaces in the residential college cafeterias was only average. Improvements need to be done to increase the sanitation level of the cafeterias, thus assuring the safety of the food for consumers.

Keywords: Food contact surfaces; microbiological contamination; sanitation level; food premise; cafeteria

ABSTRAK

Kebersihan permukaan sentuhan makanan boleh mencerminkan tahap sanitasi suatu premis makanan. Permukaan sentuhan makanan yang tercemar berserta teknik pengendalian makanan yang lemah oleh pengendali makanan boleh meningkatkan risiko berlakunya penyakit bawaan makanan melalui proses kontaminasi silang. Tujuan kajian ini adalah untuk menilai tahap pencemaran mikrobiologikal pada permukaan sentuhan makanan di 12 kafeteria kolej kediaman di sebuah universiti tempatan dan korelasinya dengan gred pemeriksaan premis. Penentuan kehadiran bakteria indikator dan patogen terpilih (kiraan plat jumlah (TVC), koliform jumlah, Escherichia coli, Staphylococcus aureus, Salmonella spp., dan Shigella spp.) pada permukaan permukaan sentuhan makanan telah dijalankan. Persampelan dijalankan ke atas papan pemotong, pisau dan utensil (kutleri, mangkuk dan pinggan) yang digunakan untuk persediaan makanan sedia dimakan. Data gred pemeriksaan premis diperoleh daripada laporan pemeriksaan premis oleh pusat kesihatan universiti. Hasil kajian mendapati bahawa terdapat 3 kafeteria yang mempunyai nilai bacaan TVC yang lebih tinggi secara signifikan (p < 0.05) berbanding dengan standard antarabangsa (1 log CFU/cm^2). E. coli hanya ditemui di 2 kafeteria manakala Salmonella spp. hanya ditemui di 7 kafeteria. Papan pemotong telah dikenal pasti sebagai permukaan sentuhan makanan yang paling tercemar manakala utensil mempunyai tahap pencemaran yang terendah. Walau bagaimanapun, hanya terdapat korelasi yang lemah di antara tahap pencemaran bakteria pada permukaan sentuhan makanan dengan gred pemeriksaan kafeteria (r = 0.02 p > 0.01). Kajian ini mendapati bahawa tahap sanitasi permukaan sentuhan makanan di kafeteria kolej yang diuji adalah hanya sederhana. Langkah penambahbaikan harus diambil bagi meningkatkan lagi tahap sanitasi kafeteria sekaligus menjamin keselamatan makanan kepada para pelanggan.

Kata kunci: Permukaan sentuhan makanan; pencemaran mikrobiologi; tahap sanitasi; premis makanan; kafeteria

INTRODUCTION

Foodborne illnesses are a constant public health concern occurring worldwide. In Malaysia, the incidence rate for food poisoning cases was 47.79 per inhabitants with 0.04 mortality rate in 2013 (Ministry of Health 2013). However, this rate might be lower than the actual incidence as such event of food borne illnesses often goes unreported in Malaysia (Soon et al. 2011). Some of the factors that contribute to foodborne illnesses cases includes ingestion of contaminated food due to cross-contamination between food products and food contact surfaces. Hence, the cleanliness of food contact surfaces could be an indicator of a food premise's sanitation level.

The presence of bacterial contaminants on food contact surfaces may increase the risk of foodborne illnesses through cross-contamination events (FDA 2014). It has been established that cross-contamination of food contact surfaces are mainly due to poor handling methods by the food handlers, which will lead to further distribution of the contamination on food products (Food Standard Agency 2009). These includes poor food storage methods, using the same kitchen tools for raw and cooked food and also ineffective cleaning procedures of the food contact surfaces (Ravishankar et al. 2010). Cross-contamination events are influenced by the microbiological contamination rate on the food contact surfaces and the probability of microbial transfer to the food products including the surrounding environmental factors such as airborne microbial transfer rate (Scott & Bloomfield 1993; Little & Sagoo 2009). A study by Kusumaningrum et al. (2003) has reported that the probability of microbial transfer from a stainless steel surface to a food product ranged from 20-80% chances. This indicates a high risk for a food product to be contaminated via food contact surfaces.

Every food handlers plays a vital role in the prevention of foodborne illnesses. The importance of effective cleaning and disinfection procedures in reducing the risk of cross-contamination is one of the key component in food safety management in the foodservice industry (Sagoo et al. 2003). The efficacy of handling and cleaning techniques by the food handlers could be monitored by microbiological sampling of the food contact surfaces. Thus, this study aimed to evaluate the microbiological contamination levels on food contact surfaces of 12 residential college cafeterias in a local university and its correlation with the cafeteria's premise grade. The presence of selected indicator and pathogenic microorganisms (total viable count (TVC), total coliform, *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp., and *Shigella* spp.) on the food contact surfaces were also determined.

MATERIALS AND METHODS

SAMPLE COLLECTION

Samples were collected from 12 residential college cafeterias in a local university. Composite surface samples were collected from five different types of food contact surfaces which are knives and cutting boards used for ready-to-eat food preparations, clean knives and cutting boards, clean utensils (composite of 3 spoons, 3 forks, 3 plates and 3 bowls). Sampling was conducted based on the methods by Christison et al. (2008) with slight modifications. A pre-moist sterile cotton swab with buffered peptone water (BPW) (Merck, Germany) was used to swab the test surfaces. Swabbing on the same test area was then repeated with a dry sterile swab. A 25 cm^2 template was used for swabbing the cutting boards, plates and bowl. For other samples, the whole area of the surface was swabbed and the surface area of the items were recorded. After swabbing, each samples were placed in a sterile tube containing 10 ml BPW. Samples were then kept at 4°C and transported back to the laboratory for further analysis.

MICROBIOLOGICAL ANALYSES

Microbiological analyses were performed according to the methods of Bacteriological Analytical Manual, BAM (2001; 2002; 2014) with some modifications. All tubes containing swab samples were vortexed and serially diluted in BPW. One hundred microliters of appropriately diluted samples were plated in duplicates on selected media; Total Viable Count – Plate Count Agar (Merck, Germany), Total coliform and *E. coli* – Chromocult Coliform Agar (Merck, Germany), *Staphylococcus aureus* – Mannitol Salt Agar (Merck, Germany), *Salmonella* spp. – XLD (Merck, Germany) and *Shigella* spp. – Salmonella Shigella Agar (Merck, Germany). All plates were incubated at 37°C for 24 hours. For detection of *Salmonella* spp., 90 ml of BPW were added to the sample and incubated at 37°C for 18 hours. Following incubation, 1 ml sample were transferred into 10 ml of Muller Kauffmann Tetrathionate Novobiocin (MKTTn) (Merck, Germany) broth and 0.1 ml of sample was also transferred into 10 ml of Rappaport-Vassiliadis Soya (RVS) (Merck, Germany) broth for further enrichment. Both tubes were incubated for 3 hours at 37°C for MKTTn and 41.5°C for RVS. 16 streak were then performed from both cultures onto *Salmonella Shigella* agar (MERCK) and incubated at 37°C for 24 hours. For negative controls, 100 µl of BPW were plated onto the media. Presumptive bacterial colonies isolated were then subjected to a series of biochemical tests for conformation where necessary (da Silva et al. 2013). All data were expressed as log CFU/cm^2 except for the detection of *Salmonella* spp. where it was reported as percentage of presence/absence of the bacteria.

Food premise inspection data were obtained from the university Health Centre. This secondary data consists of the grades that was given to the cafeterias during routine food premise inspection activities. Inspections were conducted on the same year as this study.

STATISTICAL ANALYSIS

All statistical analysis was conducted using IBM SPSS Statistic Version 21.0. Data were analyzed using 1-sample T-test to determine the differences in means with the Australian standard guideline for food contact surfaces (1 log CFU/cm^2) (NSW Government Food authority 2013) and one-way analysis of variance (ANOVA) with post-hoc comparison using Tukey test to compare the microbiological contamination level between cafeterias and food contact surfaces. Pearson product moment correlation coefficient were conducted to determine the correlation between food premise inspection data and Total Viable Counts for each cafeteria. Results were considered significant when $p < 0.05$, unless otherwise stated.

RESULTS AND DISCUSSION

Overall results (Table 1) showed that all cafeterias have exceeded the Australian standard guideline (1 log CFU/cm^2) (NSW government Food authority 2013) for the Total Viable Count (TVC) on food contact surfaces. However, only 3 cafeterias have significantly higher ($p < 0.05$) bacterial counts as compared to the standard. The highest total viable count obtained was from Cafeteria K (3.93 ± 0.48 log CFU/cm^2) followed by Cafeteria G (2.96 ± 0.30 log CFU/cm^2) and Cafeteria H (2.51 ± 0.28 log CFU/cm^2). The Australian guideline were used in this study because to date, no standard guideline on permissible microbiological levels on food contact surface is being implemented in Malaysia. Other global standards for total viable counts on food contact surfaces includes guidelines by the US Public Health Service (maximum of 10 bacterial cells per cm^2 and from United Kingdom ($\geq$ 1000 CFU/cm^2) (Sagoo et al. 2009).

TABLE 1. Bacterial contamination levels for Total Viable Counts (TVC), *Coliform*, *S. aureus* and *Shigella* spp. found on food contact surfaces of a local university residential college cafeterias. Data presented as Mean log CFU/ cm^2 ± Standard error of mean (SEM)

Cafeteria	Bacterial count, Log CFU/cm^2, (Mean ± SEM)			
	TVC	Total coliform	*S. aureus*	*Shigella* spp.
A	2.25 ± 0.48	2.44 ± 0.52	0.85 ± 0.41	2.06 ± 0.52
B	1.32 ± 0.26	0.94 ± 0.23	0.52 ± 0.09	0.36 ± 0.23
C	1.49 ± 0.44	1.18 ± 0.39	0.56 ± 0.25	0.84 ± 0.35
D	1.63 ± 0.45	0.60 ± 0.39	0.36 ± 0.14	0.45 ± 0.29
E	2.05 ± 0.39	0.96 ± 0.32	1.38 ± 0.40	0.40 ± 0.16
F	2.11 ± 0.41	0.36 ± 0.11	0.66 ± 0.26	*ND
G	2.96 ± 0.30	1.89 ± 0.42	0.51 ± 0.24	1.39 ± 0.38
H	2.51 ± 0.28	1.10 ± 0.30	0.82 ± 0.26	0.66 ± 0.19
I	2.42 ± 0.41	1.98 ± 0.32	1.16 ± 0.36	1.55 ± 0.26
J	2.15 ± 0.37	1.61 ± 0.28	0.40 ± 0.21	0.71 ± 0.31
K	3.93 ± 0.48	2.52 ± 0.52	1.64 ± 0.52	1.77 ± 0.56
L	2.00 ± 0.38	1.34 ± 0.22	0.74 ± 0.26	0.73 ± 0.21

*ND- not detected

Total coliform was found at all cafeterias with the highest reading was recorded at Cafeteria K (2.52 ± 0.52 log CFU/cm^2) and the lowest was at Cafeteria F (0.36 ± 0.11 log CFU/cm^2). No *Shigella* spp. was found in Cafeteria F whereas *E. coli* was only found in Cafeteria I (0.60 ± 0.30 log CFU/cm^2) and Cafeteria K (1.21 ± 0.54 log CFU/cm^2) on tested cutting boards (clean and used) and used knives. Meanwhile, *Salmonella* spp. was only detected on 7 of the cafeterias (C, E, G, H, I, J, and K) and was mostly found on tested clean cutting boards (46.7%) (Figure 1).

One of the sources of microbiological contamination on the food contact surfaces in this study may be due to cross-contamination from contaminated raw food products onto the contact surfaces and also from the hands of the food handlers, especially those who did not apply good personal hygiene practices (Gorman et al. 2002; Kusumaningrum et al. 2003). A study by Clayton et al. (2002) has concluded that time is one of the contributing factor to poor hygiene practices whereby food handlers reported that they have limited time to spend on washing their hands and the contact surfaces frequently. It is also essential for every food handler to use separate utensils when handling raw and ready-to-eat food products (FDA 2015). However, this practice is commonly neglected by the food handlers as
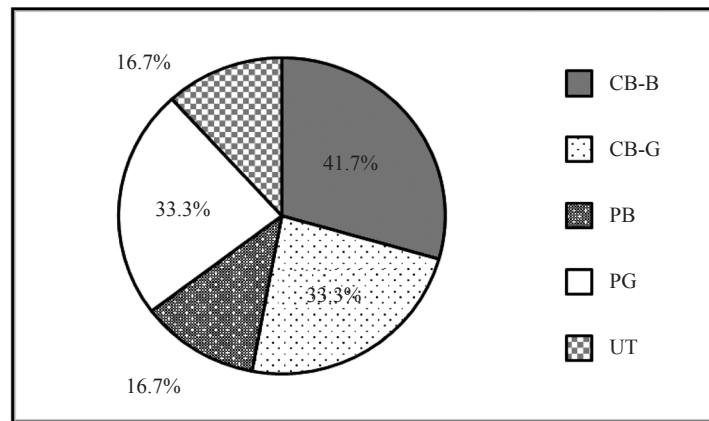
FIGURE 1. Percentage of *Salmonella* spp. presence on different type of food contact surfaces. (CB-B- clean cutting boards; CB-G- used cutting boards; PB- clean knives; PG- used knives and UT-utensils)

reported by published studies whereby 25-81% of food handlers admitted that they use the same utensils such as cutting boards to handle raw meat and ready-to-eat food without cleaning them beforehand (Klontz et al. 1995; Redmond & Griffith 2003). Such practices would increase the probability of cross-contamination to occur.

In this study, cutting boards has been identified as the most contaminated food contact surface whereas utensils were the least contaminated (Figure 2). The data also showed that the TVC for clean cutting boards were found to be significantly higher than the TVC for clean knife and utensils ($p < 0.05$). Cutting boards (clean and used) were also found to have a significantly higher numbers of total coliform as compared to other food-contact surfaces ($p < 0.05$). No significant differences of *Shigella* spp. counts were observed between all type of food contact surfaces ($p > 0.05$). Besides that, no *S. aureus* were detected on tested utensils from all cafeterias.

Based on the high levels of microorganisms found on the cutting boards, it can be suggested that this tool is highly potential to be the primary source of cross-contamination events in the residential college cafeterias. These microorganisms can be further transferred to food products or other food contact surfaces (Carrasco et al. 2011). It should also be noted that the type of cutting boards could also influence the contamination rate of this contact surface. Most cafeterias sampled in this study, uses wood cutting boards which has been known to have a higher risk of bacterial attachment to the surface as compared to the other types due to its ability to entrap microorganisms within the wood fibers (Carrasco et al. 2011; Soares et al. 2012).

Inefficient cleaning procedures and storage method could also explain the high levels of microorganisms found on cutting boards that has been cleaned in this study (Little & Sagoo 2009; Manan et al. 2009). This
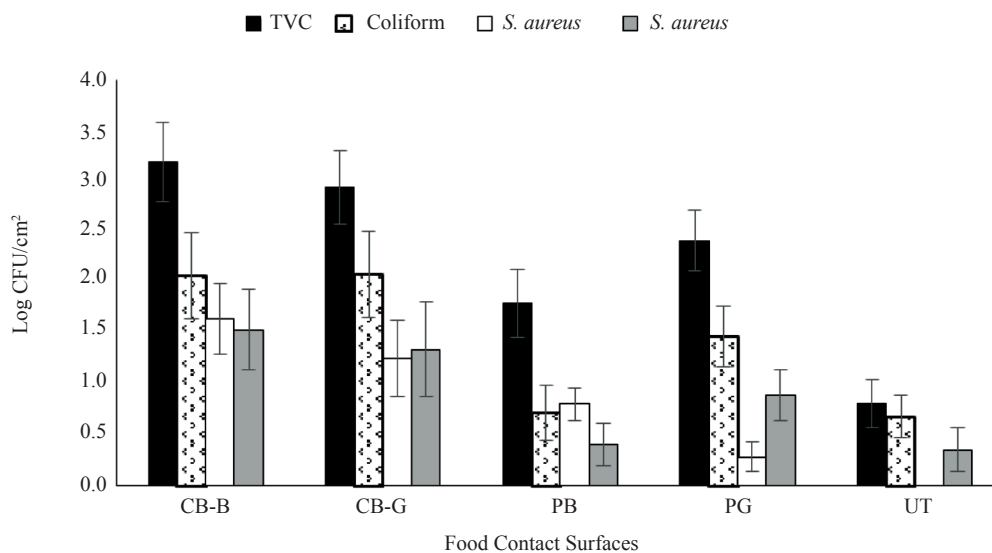

FIGURE 2. Mean log CFU/cm² for Total Viable Counts (TVC), Total coliform, *S. aureus* and *Shigella* spp. on different type of food contact surfaces. (CB-B- clean cutting boards; CB-G- used cutting boards; PB- clean knives; PG- used knives and UT-utensils). Error bars denote standard error of mean

could further increase the risk of foodborne illnesses as studies shown that microbes such as *E. coli, S. aureus and Salmonella* spp. can remain viable for a long period of time on food contact surfaces (Kusumaningrum et al. 2003). The hygiene level of the washer's sponge could also contribute to the effectiveness of cleaning procedures (Manan et al. 2009).

Based on the Pearson product moment correlation analysis, there was only a weak correlation between the number of microorganisms found on food contact surfaces and the cafeteria's inspection grade (r = 0.02 $p > 0.01$). This weak correlation could be attributed to the cafeteria's scoring method used by the health officers from the university health centre. Grades were only given based on gross observations on certain set parameters but no microbiological sampling were conducted on the cafeteria's food contact surfaces. Despite no visible contamination, a food contact surfaces may still harbours a high level of microorganisms which can only be determined through microbial analysis of the food contact surfaces.

CONCLUSION

This study demonstrated that the sanitation level of food contact surfaces in the university residential's college cafeterias was only average. The importance of the cleanliness of food contact surfaces should be emphasized by every food handlers and also the monitoring authorities of the residential college cafeterias. It is recommended that periodic assessment on the sanitation level of food contact surfaces to be included in regular cafeteria inspection activities. A refresher training on the proper cleaning and disinfection techniques should be provided for the food handlers. These activities could help in increasing the sanitation level of the cafeterias, thus assuring the safety of the food for consumers especially the university students.

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