International Food Research Journal 31(3): 658 - 669 (June 2024)
Journal homepage: *http://www.ifrj.upm.edu.my*

Microbial assessment on cutting boards and cleanliness levels of restaurants with long operating hours around Klang Valley, Malaysia

[1,3]Shafizi, A. W., [1]*Sahilah, A. M., [2]Chai, L. C., [1]Razalee, S. and [1]Aishah, E.

[1]Faculty of Science and Technology, National University of Malaysia, 43600 Bangi, Selangor, Malaysia
[2]Chancellery Office, Sunway University, 47500 Bandar Sunway, Selangor, Malaysia
[3]Ministry of Health, 62590 Putrajaya, Malaysia

Article history

Received:
26 June 2023
Received in revised form:
24 March 2024
Accepted:
27 March 2024

Keywords

long-hour restaurant, cleanliness level, cutting board, Salmonella spp., Staphylococcus aureus

Abstract

Cutting boards used for ready-to-eat (RTE) foods in most restaurants are often contaminated with bacteria, leading to foodborne illnesses. The present work aimed to detect the contamination of aerobic bacteria, coliform, *Escherichia coli*, *Salmonella* spp., and *Staphylococcus aureus* on cutting boards, and to evaluate the levels of cleanliness of long-hours restaurants around Klang Valley, Malaysia. The examination of bacterial contamination was conducted by swabbing cutting boards from 33 restaurants. The findings showed that the numbers of aerobic bacteria were within the range of 3.95 to 7.07 $\log_{10}$ CFU/cm^2, namely coliform (< 1.00 to 5.58 $\log_{10}$ CFU/cm^2), *E. coli* (< 1.00 $\log_{10}$ CFU/cm^2), *S. aureus* (< 1.00 to 2.90 $\log_{10}$ CFU/cm^2), and *Salmonella* spp. They were detected from 12% (n = 4/33) of cutting boards. At the same time, the levels of restaurants' cleanliness were A at 3% (n = 1/33), and both B and C at 48.5% (n = 16/33). There was no significant ($p > 0.05$) association between the contamination of coliform (χ^2 = 1.096), *Salmonella* spp. (χ^2 = 0.004), and *S. aureus* (χ^2 = 0.437) with the levels of restaurants' cleanliness. Therefore, the present work concluded that the contamination of bacteria on the cutting boards was not affected by the levels of cleanliness based on swabbing food contact surfaces to evaluate the microbial status.

DOI
https://doi.org/10.47836/ifrj.31.3.11

Introduction

It is generally estimated that more than one-third of the world's population has been affected by foodborne diseases (Mohammed *et al.,* 2020). Uyttendaele *et al.* (2015) showed that low- and middle-income countries have higher tendency to experience foodborne diseases due to high intake of unsafe foods, especially fresh products, fish products, and livestock. The incidence of foodborne diseases is often associated with dirty premises, contaminated food equipment or contact surfaces, and unsanitary food handling practices. These practices often lead to cross-contamination and other risky conditions.

Cutting board is one of the common food contact surfaces used in food premises for food handling. Examples of cutting board materials are wood, plastic, glass, and stainless steel. Generally, microorganisms can stick or accumulate on the cutting board. They can remain or form biofilm even after cleaning and disinfection activities. This poses a risk to consumers if microorganisms from the cutting boards are transferred to ready-to-eat (RTE) foods, though they have undergone heating process (Takooree *et al.,* 2019). Siti Shahara *et al.* (2018) explained that the cleanliness of the food contact surfaces, including cutting boards, can be used as an indicator of the cleanliness of the food premises. The presence of bacteria on food contact surfaces may increase the risk of foodborne diseases through cross-contamination. A study conducted at a public university in Malaysia has shown that cutting boards were identified as the most contaminated food contact surfaces with bacteria compared to other utensils (Siti Shahara *et al.*, 2018).

Apart from cutting boards or other utensils that come in direct contact with foods, the cleanliness of food premises is also crucial to avoid foodborne infectious diseases. According to Lynch *et al.* (2003) and Knight *et al.* (2007), restaurants are among the food premises identified as the cause of foodborne disease outbreaks. Therefore, an inspection of restaurants is vital to ensure that the premises are always in a clean condition (Mohd Rejab *et al.*, 2015)

*Corresponding author.
Email: sahilah@ukm.edu.my

and safe for consumers (Medu *et al.*, 2016). In Malaysia, there are food premises that operate until late at night, even continuously, 24 hours a day, to meet the needs of consumers in the city. Hassan *et al.* (2015) suggested that more extensive research should be conducted on food premises regarding the level of grading as it can have a positive impact on the community, especially in raising awareness, and this will indirectly reduce the number of cases of foodborne infection.

Therefore, the purpose of the present work was to detect the contamination status of aerobic bacteria, coliform, *Escherichia coli*, *Salmonella* spp., and *Staphylococcus aureus* on cutting boards, and evaluate the levels of cleanliness of long-hour restaurants around Klang Valley, Malaysia. The present work also determined the association between the levels of bacterial contamination on cutting boards and the cleanliness of long-hour restaurants assessed.

Materials and methods

Study design

The cross-sectional study design was carried out in eight months, from May to December 2022. This study involved 33 (n = 33) restaurants and 117 foreign food handlers located around Klang Valley. Among the food handlers, 83 were Indians originating from India, 12 were Indonesians, ten were Bangladeshis, nine were Burmese, and three were from other countries. The sampling method was quantitative, which included applying surface swabs on cutting boards using a 3M™ Environmental Scrub Sampler (ESS). The cutting boards chosen were collected from ready-to-eat (RTE) food areas from each restaurant. Simultaneously, the inspection of restaurants was selected for restaurants which operated for more than 18 hours. The inspection was conducted by filling out the Food Premise Inspection Form (JKT/KS/1) based on the Guidelines on Food Premises Grading System in the Local Authority Area issued by the Ministry of Housing and Local Government (KPKT, 2014). The restaurants selected were registered in the local authority database, except for fast food restaurants.

Microbial sampling techniques

Cutting board surfaces were swabbed using 3M™ ESS containing 10 mL of 3M™ Wide Spectrum Neutralizer, following the manufacturer's instruction. Swabbing was done by pressing the ESS down, and the stick was flexed, ensuring full contact. The organic matter present was disrupted by the vigorous scouring in a zigzag motion across the entire cutting board surface. The sample area was approximately 10 × 10 cm. The swabbing procedure was repeated by turning over the device to the other side, and the sampling direction changed to 90° (3M, U.S.A). The swabs were then placed and fastened into a sample bag, and placed into an ice box with a temperature range between 0 and 4°C. Samples were transported from restaurants to the laboratory, and analysed within 24 h.

Samples were diluted from 10^{-1} to 10^{-5} using buffer peptone water (Merck, U. S. A), and then vortexed (Velp Scientifica, Italy). Then, 1 mL of samples from each dilution was inoculated onto the 3M™ Petrifilm for Aerobic Count Plate (AC), *Escherichia coli*/Coliform Count Plate (ECC), *Salmonella* Express Plate (SALX), and *Staph* Express Count Plate (STX) (3M, USA). The AOAC official method was used for incubation: aerobic bacteria (method 990.12), *E. coli* and coliform (method 991.14), *Salmonella* spp. (method 2014.01), and *S. aureus* (method 2003.07); colony counts were reported as log CFU/cm^2. The presence of colonies was classified into two categories: "satisfactory" for < 1.30 $\log_{10}$ CFU/cm^2 (aerobic), < 1.00 $\log_{10}$ CFU/cm^2 (coliform, *E. coli*, and *S. aureus*); and "unsatisfactory" for ≥ 1.30 $\log_{10}$ CFU/cm^2 (aerobic), ≥ 1.00 $\log_{10}$ CFU/cm^2 (coliform, *E. coli*, and *S. aureus*); based on Sneed *et al.* (2004) and Marzano and Balzaretti (2011). For *Salmonella* spp., it would be presented as "detected" or "not detected".

Restaurant inspection

The inspection determined the levels of cleanliness and grades as A, B, and C. The inspection form (JKT/KS/1) consisted of seven main components comprising 31 items for evaluation. The main components of the inspection are the food preparation areas, food serving areas, food handlers, water supply system, sanitation system, structure and maintenance of premises, and other related important components. Grading was determined based on the inspection score. Grade A (86 - 100%) was rated as "very clean", grade B (71 - 85%) was rated as "clean", grade C (51 - 70%) was rated as "less clean", and ungraded rate was given for a score below 51%. The reassessment of the ungraded premises must be carried out within 14 days. As for statistical analysis

purpose, the classification of cleanliness level was then divided into the "clean" category for marks more than 70%, while the scores 70% and below were classified as "less clean".

Data analysis

The microbial analysis and restaurant inspection data collected were entered into a specifically designed database (Excel 2010, Microsoft) for analysis. Further studies were conducted using IBM SPSS statistical software version 20 (IBM Corp, Armonk, New York) to determine the significant association between the levels of bacterial contamination and the levels of cleanliness of restaurants. The Fisher's Exact test was chosen, and a *p*-value of < 0.05 was considered to be statistically significant. Meanwhile, the descriptive results were presented in mean, standard deviation, and percentages.

Ethical approval

Approval for the study was granted by the Secretariat Committee of Medical Research and Innovation of Hospital Canselor Tuanku Mukhriz, National University of Malaysia Medical Centre (Project Reference UKM/PPI/111/8/JEP-2019-737) and National Medical Research Register, Ministry of Health Malaysia (Research ID-22-00393-8MF).

Results

Microbial analysis of cutting boards

The analysis found that the number of bacterial colonies on cutting boards were aerobic bacteria within a range of 3.95 to 7.07 $\log_{10}$ CFU/cm^2, namely coliform (< 1.00 to 5.58 $\log_{10}$ CFU/cm^2), *E. coli* (< 1.00 $\log_{10}$ CFU/cm^2), *S. aureus* (< 1.00 to 2.90 $\log_{10}$ CFU/cm^2), and *Salmonella* spp. were detected in 12% (n = 4/33) of cutting boards. In terms of classification, *E. coli* was classified as "satisfactory", which recorded 0% (n = 0/33), as well as *S. aureus* with 9% (n = 3/33) of cutting board. Meanwhile, aerobic and coliform were classified as "unsatisfactory" with values of 100% (n = 33/33) and 97% (n = 32/33), respectively. As for *Salmonella* spp., the evaluation was presented as "detected" or "not detected" (Table 1).

Table 1. Microbial loads (CFU/cm^2) of indicator microorganisms.

Indicator microorganism	Status	Number of cutting board	Percentage (%)	Min[a] ($\log_{10}$ CFU/cm^2)	Max[a] ($\log_{10}$ CFU/cm^2)
Aerobic Count[b]	Unsatisfactory	33	100	3.95	7.07
	Satisfactory	0	0	0.00	0.00
Coliform Count[c]	Unsatisfactory	32	97	1.00	5.58
	Satisfactory	1	3	< 1.00	< 1.00
E. coli Count[d]	Unsatisfactory	0	0	0.00	0.00
	Satisfactory	33	100	< 1.00	< 1.00
S. aureus Count[e]	Unsatisfactory	3	9	1.48	2.90
	Satisfactory	30	91	< 1.00	< 1.00
Salmonella spp.	Detected	4	12	NA	NA
	Not detected	29	88	NA	NA

[a]Minimum and maximum CFU/cm^2; [b]Aerobic Count threshold is based on Sneed *et al.* (2004) and Marzano dan Balzaretti (2011) which is ≥ 1.30 $\log_{10}$ CFU/cm^2; [c]Coliform Count threshold is based on Sneed *et al.* (2004) and Marzano dan Balzaretti (2011) which is ≥ 1.00 $\log_{10}$ CFU/cm^2; [d] *E. coli* Count threshold is based on Sneed *et al.* (2004) and Marzano dan Balzaretti (2011) which is ≥ 1.00 $\log_{10}$ CFU/cm^2; [e]S. *aureus* Count threshold is based on Sneed *et al.* (2004) and Marzano dan Balzaretti (2011) which is ≥ 1.00 $\log_{10}$ CFU/cm^2; and NA: not applicable; total number of cutting boards: 33.

Restaurants' cleanliness

The results of the cleanliness levels of restaurants showed that only 3% (n = 1/33) of premises obtained grade A, and 48.5% (n = 16/33) were recorded as both grades B and C. The mean score value for all restaurants was 71.85 ± 7.75%. The minimum score value was recorded at 57%, and the maximum score was recorded at 94%. The results showed that 51.5% of the restaurants were at "clean", and 48.5% were "less clean".

Based on the 31 elements, nine elements were recorded below 51% (Table 2). Table 2 shows the mean score for elements that affected the levels of cleanliness of restaurants in the area of the study. As indicated in Table 2, the nine aspects with mean scores from lowest to highest were: "Enough trash bin, covered, clean and packed" (mean value = 0.00 ± 0.00%); followed by "Health check on all food handlers" (mean value = 9.09 ± 29.19%); "The premises and equipment should be well maintained, and the cleaning schedule should be monitored continuously" (mean value = 24.24 ± 43.52%); "Hygiene of refrigerator" (mean value = 26.26 ± 27.33%); "The space between the appliance and the wall/floor" (mean value = 36.36 ± 48.85%); "Foods and chemicals should be stored separately, both must be labelled" (mean value = 42.42 ± 50.19%); "Floor, wall and ceiling conditions" (mean value = 43.63 ± 33.21%); "Wiping cloths, pads and cutting tools" (mean value = 45.45 ± 47.37%); and lastly "Effective pest control" (mean value = 46.97 ± 49.91%). Meanwhile, the remaining 22 elements had a mean score of more than 50%.

Association between microbial contamination and cleanliness level

Fisher's exact test determined the association between the microbial contamination levels on the cutting board and the restaurant's cleanliness levels (Table 3). Results showed no significant association between the bacterial contamination of coliform, *Salmonella* spp., and *S. aureus* on cutting boards and the levels of cleanliness in the studied area ($p > 0.05$; $\chi^2 = 1.096$; $\chi^2 = 0.004$; and $\chi^2 = 0.437$). This implied that the levels of restaurant cleanliness did not reflect the status of bacterial contamination on cutting boards, or *vice versa*.

Discussion

The present work aimed to evaluate the bacterial contamination status of cutting boards and the cleanliness levels of restaurants with long operating hours. To the best of our knowledge, this study was the first to be conducted in Malaysia that involved long operating hour restaurants. Food handler is the key player in determining the cleanliness levels of a restaurant, which is prone to getting contaminated, especially on the studied kitchen tool and cutting board with main pathogens causing foodborne illnesses such as aerobic bacteria, coliform, *E. coli*, *Salmonella* spp., and *S. aureus.*

Microbial analysis determined that cutting boards from many restaurants assessed in the present work were commonly contaminated with bacteria. Counts of aerobic bacteria in cutting boards were 3.95 to 7.07 $\log_{10}$ CFU/cm^2, which was higher than the study reported in other food premises in Terengganu, Malaysia (2.5 ± 0.07 to 6.0 ± 0.01 $\log_{10}$ CFU/cm^2) and Wales (2.4 to 6.1 $\log_{10}$ CFU/cm^2) (Hamat *et al.,* 2019; Evans and Redmond, 2019). Meanwhile, counts for coliform (< 1.00 to 5.58 $\log_{10}$ CFU/cm^2) were higher compared to Hamat *et al.* (2019) (< 1.00 to 3.2 ± 0.01 $\log_{10}$ CFU/cm^2), but lower than Faour-Klingbeil *et al*. (2016) in Lebanon restaurants with value < 1.00 to 8.40 $\log_{10}$ CFU/cm^2. However, in the present work, for *E. coli*, the result (< 1.00 $\log_{10}$ CFU/cm^2) was below the findings of previous works with values of 1.1 ± 0.17 $\log_{10}$ CFU/cm^2 and 2.4 to 5.0 $\log_{10}$ CFU/cm^2 (Hamat *et al.,* 2019; Evans and Redmond, 2019), respectively. Whereas, for *S. aureus* (< 1.00 to 2.90 $\log_{10}$ CFU/cm^2), the value was below as compared to Faour-Klingbeil *et al*. (2016) which < 1.00 to 8.40 $\log_{10}$ CFU/cm^2.

Aerobic and coliform counts were expected to be higher due to the long hours of operation of restaurants. At the same time, lower values of *E. coli* and *S. aureus* at those restaurants' cutting boards could have been due to personnel hygiene practices among food handlers, as discussed later. The prevalence of bacterial colonies could have been due to cross-contamination from the food handlers' practices of placing kitchen tools on cutting boards after use, such as food clips and knives. Based on observation, these items were unsanitary when they were left on the cutting boards, and reused when needed. Also, contamination could occur due to the exposure of cutting boards to open air or cutting boards not covered after use. This observation was in line with a study conducted in food premises in Terengganu, Malaysia, which showed contamination of bacteria for knives used together with cutting boards being 0.96 ± 1.01 to 4.19 ± 0.20 $\log_{10}$ CFU/cm^2 (Mohd Nizam *et al*., 2014). Another study by Little and Sagoo (2009) proved that the rate of microbial contamination on the food contact surfaces influenced cross-contamination, as food contamination could increase after being in contact

Table 2. Mean scores for elements affecting the cleanliness level of restaurants.

Element	Mean (%)	SD	Min (%)	Max (%)
Food Preparation Area				
Temperature regulation for food preparation and storage	96.97	17.41	0.00	100.00
Effective pest control*	46.97	49.91	0.00	100.00
Hygiene of refrigerators*	26.26	27.33	0.00	100.00
Hygiene of cooking equipment and facilities	67.68	21.22	33.33	100.00
Smoke and heat release systems	90.91	19.58	50.00	100.00
Spaces between the appliance and the wall/floor*	36.36	48.85	0.00	100.00
Food Serving Area				
Temperature control and place of display of food is according to the conditions and types of food	87.88	33.14	0.00	100.00
Culinary equipment used for food delivery	84.85	26.47	0.00	100.00
Wiping cloths, pads, and cutting tools*	45.45	47.37	0.00	100.00
Tables, chairs, and equipment	96.97	17.41	0.00	100.00
Food Handler				
Health check on all food handlers*	9.09	29.19	0.00	100.00
Good level of personal hygiene	54.04	17.19	16.67	100.00
No health problem related to food contamination	87.88	33.14	0.00	100.00
Water Supply System				
Safe source of water supply	100.00	0.00	100.00	100.00
Use of water supply	90.91	23.23	0.00	100.00
No pipe leakage on the premises	100.00	0.00	100.00	100.00

Element	Mean (%)	SD	Min (%)	Max (%)
Sanitation System				
Condition of toilet facilities	78.28	14.12	50.00	100.00
Sufficient facilities	66.67	28.87	33.33	100.00
Hand washing facilities	76.77	19.52	33.33	100.00
Premise Structure and Maintenance				
Floor, wall, and ceiling conditions*	43.03	33.21	0.00	100.00
Ventilation and lighting	100.00	0.00	100.00	100.00
Ideal drainage system	81.82	32.64	0.00	100.00
Perfect wastewater management system	77.27	37.69	0.00	100.00
Others				
Customer feedback	100.00	0.00	100.00	100.00
Enough trash bins, covered, clean, and packed*	0.00	0.00	0.00	0.00
Foods and chemicals should be stored separately. Both must be labelled*	42.42	50.19	0.00	100.00
Good store preparation and management	59.60	27.33	33.33	100.00
Good solid waste management practices (isolation at source)	84.85	36.41	0.00	100.00
Premises and equipment should be well maintained, and the cleaning schedule should be monitored continuously*	24.24	43.52	0.00	100.00
Notice of hygiene notice, safety practices, health education and smoking ban	96.97	17.41	0.00	100.00
Control and safety at food premises	96.97	9.73	66.67	100.00

*Nine elements below 51% mean scores, (n = 33).

Table 3. Association between bacterial contamination levels on cutting board and cleanliness levels of restaurants.

Cleanliness level	Coliform				*S. aureus*				*Salmonella* spp.			
	Unsatisfactory	Satisfactory	χ^2	*p*	Unsatisfactory	Satisfactory	χ^2	*p*	Detected	Not detected	χ^2	*p*
Less clean[a]	15	1	1.096	0.485	2	14	0.437	0.601	2	14	0.004	1.000
Clean[b]	17	0			1	16			2	15		

Significant at $p < 0.05$. [a]Less clean level, marked at ≤ 70%; [b]Clean level, marked at > 70%, ($n = 33$).

with a contaminated surface. Other factors could affect the contamination rate, such as the rate of bacterial contamination through the air.

Food waste that was not cleaned and left for too long could also cause bacterial growth on the cutting boards. This agreed with Larsen *et al*. (2014) who stated that the development of pathogens could occur when the surfaces of food came into contact with pathogenic colonies, and they multiplied. The bacteria could have high survival rate for a long period to form biofilm (Campdepadros *et al.*, 2012) on the surface of the equipment, and the environment of the food processing site. Hamat *et al.* (2019) explained that the high prevalence of aerobic and coliform bacteria on food contact surfaces, especially cutting boards, indicated that the cleaning and disinfection procedures were insufficient. The cleaning method found in a study done in Cardiff by Evans and Redmond (2019) stated that the majority (63%) reported that their chopping boards were cleaned by washing in the sink with hot, soapy water; 23% reported that a dishwasher was usually used to wash the chopping boards. The majority of chopping boards (55%) were plastic, 28% were wooden, and the rest were glass and marble. No significant differences ($p > 0.05$) were determined in the microbial loads of chopping boards based on the material of the chopping boards. Self-reported cleaning methods were also determined to have no significant difference ($p > 0.05$) in microbiological contamination.

It is thus recommended to review and improve the procedures and frequency of cleaning as well as the usage of disinfectant materials so that the cutting boards are completely clean and free from bacterial contamination before used. This agreed with Goncalves *et al*. (2013) who stated that the effectiveness of cleaning and disinfection procedures on food contact surfaces should be carried out before, during, and after use to reduce the risk of cross-bacterial contamination with equipment.

The detection of *Salmonella* spp. in the present work was supported by Takooree *et al.* (2019) who reported the presence of *Salmonella* spp. on plastic cutting boards at 2.3 ± 0.71 $\log_{10}$ CFU/cm^2, while on glass and wood cutting boards at $< 1.6 \pm 0.00$ $\log_{10}$ CFU/cm^2. Based on the observations, flurried flies and Eurasian tree sparrow birds were there for leftover foods on several cutting boards used for RTE food preparation, which were exposed to outside open-air during restaurant inspection. Therefore, the presence of *Salmonella* spp. on the cutting boards could have been contributed by vectors such as flies and birds perching on them. Flies play an important role in transmitting bacteria from sources of pollution, such as toilets and unsanitary drainage systems, as well as uncovered waste bins to the surface of the cutting boards. This finding was supported by Hood and Zottala (1997) and Chessbrough (2000) who reported flies as a main vector of cross-contamination of bacteria. It also stated that the discovery of *Salmonella* spp. on the cutting boards was also due to the presence of bacteria on the "knife scars" or scratches seen on the surface of the analysed equipment (Takooree *et al.*, 2019). It is thus recommended that the cutting boards be covered every time it is used to prevent cross-contamination.

In terms of restaurant grading, the findings showed that the majority of the restaurants were graded B and C after the inspection. This could have been due to the lack of staff in managing the cleaning activities of the restaurants, and the increased number of customers after the Movement Control Order (MCO) period was terminated by the Government during the COVID-19 pandemic. The increased number of customers would result in higher food handling operations, and indirectly caused the food handlers to be overwhelmed to carry out cleaning activities efficiently and effectively. The Grade B restaurants were labelled as “clean”, while grade C restaurants were labelled as “less clean”. The grade B restaurants could sometimes be downgraded to grade C the next day of inspection when there were no immediate actions taken to improve the cleanliness level. Restaurants graded C had the highest chances of exposing their customers to foodborne illnesses. This finding ($71.85 \pm 7.75\%$), which was classified as “clean” level, was supported by Kaur *et al.* (2021) who recorded a clean level of food premises cleanliness in Kota Kinabalu, Sabah, Malaysia, with the value of 80.75%.

The inspection results showed that the main elements contributing to the low level of restaurant cleanliness were related to "Enough trash bin, covered, clean and packed", "Health check on all food handlers", "The premises and equipment should be well maintained, and the cleaning schedule should be monitored continuously", "Hygiene of refrigerator", and "The space between the appliance and the wall/floor". There were also bins left open, which contributed to the presence of pests such as rats, flies,

and cockroaches. The low-level scores were affected by 29.9% food handlers who did not get anti-typhoid vaccination, and 34.2% who had yet to attend the food handler course. Based on the inspection, it was seen that the frequency of cleaning activities of the restaurants did not comply with the prescribed cleaning schedule, and the level of cleanliness of the refrigerator was not satisfactory. Similarly, the condition of the plentiful equipment and utensils, especially in the restaurant store, had caused the space between appliances and the wall or floor to be limited for movement and cleaning activities. Therefore, these factors need to be taken seriously with the explanation and guidance to the food handlers to ensure that the same setback will not happen again.

The importance of these factors is supported by the study by Kaur *et al*. (2021) which recorded the following percentage of non-compliance with elements in the inspection of food premises. Among them were "Enough trash bin, covered, clean and packed" (62.7%), "Health check on all food handlers" (56.5%), "The premises and equipment should be well maintained, and the cleaning schedule should be monitored continuously" (34.3%), "Hygiene of refrigerator" (68.3%), and "The space between the appliance and the wall/floor" (45.1%). Due to these issues, monitoring of food handler practices is important as it is the main reason for a premises failing to achieve a good level of hygiene. Therefore, the food handlers should play a prominent role in developing a food safety culture among them (Ncube *et al*., 2020) by avoiding unhygienic and unsafety food handling practices. It is also suggested that the food handlers fix the duration for effective cleaning at least once a day, and this activity should be included in the restaurant licencing requirement.

For enforcement activity, it is also recommended that inspections of the restaurants be conducted regularly at different frequencies depending on the grade of the restaurant. For instance, the frequency of inspection for grade C premises is once every six months, while grade B is once a year. This recommendation is in line with a study by Wahida *et al.* (2017) which stated that more frequent inspections of food premises are crucial to maintaining hygiene levels, and can have a remarkable effect on the number of food poisoning cases. This is because the level of awareness related to food safety among food handlers will increase after being advised or reminded by the inspector.

Overall findings showed no significant association between the contamination levels of coliform, *Salmonella* spp., and *S. aureus* on the cutting boards and the cleanliness levels of restaurants in the locality of the study ($p > 0.05$; $\chi^2 = 1.096$; $\chi^2 = 0.004$; $\chi^2 = 0.437$). This was in line with the survey by Nurul Shuhada *et al.* (2019) who stated that there was no significant difference between mean number of microbial colonies on food contact surfaces and the levels of cleanliness of food premises either over or below 70% ($p = 0.49$; 95%; CI 79.93; 41.15). Similarly, a study by Faour-Klingbeil *et al*. (2016) in Beirut, Lebanon, reported no significant correlation between the number of bacteria on the food contact surfaces and the restaurant hygiene levels ($p > 0.05$). However, this contradicted Siti Shahara *et al.* (2018) on the correlation between bacterial contamination levels on food contact surfaces and hygiene levels or inspection grades of residential college cafeterias at a public university in Malaysia, who showed weak correlation results of $r = 0.02$ and $p < 0.01$. A study by Shafizi *et al.* (2016) related to the evaluation of ready-to-eat foods showed no significant correlation between the presence of *S. aureus* and the levels of cleanliness of restaurants in Putrajaya ($r = - 0.113$; $n = 106$; $p > 0.01$).

Besides, there was no association between the levels of bacterial contamination and the levels of cleanliness in restaurants; the other aspect to look at is the cleaning aspect of applying a disinfection process at the restaurants. Using disinfection may not eliminate bacteria attached to the surface of the equipment by normal cleaning methods and insufficient disinfection processes. Hultman *et al.* (2015) showed that the presence of microorganisms in the form of biofilm on the surface would be difficult to eliminate, and persistent contamination would increase the attachment of pathogenic bacteria. This agreed with Maes *et al*. (2019) who emphasised the importance of optimal and effective cleaning and disinfection procedures to reduce or eliminate bacteria. Phillips (2016) stated that the use of chemicals for disinfecting activities can routinely minimise the spread of bacteria on food contact surfaces.

Conclusion

Microbial analyses revealed that the cutting boards were frequently contaminated with high

counts of bacteria, indicating the need to replace them more regularly. Most of the restaurants were graded as clean, with half of them at the bottom level that needed improvement. In the present work, there was no significant association between the levels of bacterial contamination and the cleanliness levels of restaurants, indicating that the presence of coliform, *Salmonella* spp., and *S. aureus* on the cutting boards was not affected by the restaurants' levels of cleanliness. Consequently, the findings of the present work may assist Malaysian authorities in developing and improving existing legal provisions and public policies. Instruction manuals for food premises can also be developed for proper and standardised cleaning activities. Surface swabs are also important for inspecting the premises for evidence-based practices, and as an indicator of bacterial contamination status.

Acknowledgement

The authors would like to acknowledge the contributions of all the agencies involved namely the National University of Malaysia (UKM), Kajang Municipal Council (MPKj), and Ministry of Health (MOH). The authors also appreciate all the restaurant owners and food handlers who participated in the present work.

References

Campdepadros, M., Stchigel, A. M., Romeu, M., Quillez, J. and Sola, R. 2012. Effectiveness of two sanitation procedures for decreasing the microbial contamination levels (including *Listeria monocytogenes*) on food contact and non-food contact surfaces in a dessert-processing factory. Food Control 23(1): 26-31.

Chessbrough, M. 2000. District laboratory practice in tropical courtiers - Part 2. United Kingdom: Cambridge Press.

Evans, E. W. and Redmond, E. C. 2019. Domestic kitchen microbiological contamination and self-reported food hygiene practices of older adult consumers. Journal of Food Protection 82(8): 1326-1335.

Faour-Klingbeil, D., Todd, C. D. E. and Kuri, V. 2016. Microbiological quality of ready-to-eat fresh vegetables and their link to food safety environment and handling practices in restaurants. LWT - Food Science and Technology 74: 224-233.

Goncalves, J. M., Rodrigues, K. L., Demoliner, F. and Rossales, R. 2013. Hygienic and sanitary conditions in the hospital foodservice: Relationship between good practices and microbiological quality. Journal of Food Safety 33: 418-422.

Hamat, H. W., Lani, M. N., Hamzah, Y., Alias, R. and Hassan Z. 2019. Microbiological assessment of keropok lekor production in Kuala Terengganu and Marang, Malaysia. Asian Journal of Agriculture and Biology 7(1): 74-85.

Hassan, H., Jamil, J., Arsat, A., Saidatul-Afzan, A. A. and Chang, F. S. 2015. Consumers' understanding and perception on the use of food premise grading system. In Proceedings of the 2nd International Hospitality and Tourism Conference 2014, p. 415-420. Penang, Malaysia.

Hood, S. K. and Zottala, E. A. 1997. Adherence of stainless steel by food-borne microorganisms during growth in model food systems. International Journal of Food Microbiology 37: 145-153.

Hultman, J., Rahkila, R., Ali, J., Rousu, J. and Bjorkroth, K. J. 2015. Meat processing plant microbiome and contamination patterns of cold-tolerant bacteria causing food safety and spoilage risks in the manufacture of vacuum-packaged cooked sausage. Applied and Environmental Microbiology 81: 7088-7097.

Kaur, N., Wafaak, E., Yanti, Z., Dony, J. F., Syed Sharizman, S. A. R., Mohammad Saffree, J., ... and Zulkahirul Naim, S. A. 2021. Factors of food premise not attaining "A" grading in Sabah, Malaysia Borneo. Universal Journal of Public Health 9(5): 339-343.

Knight, A. J., Worosz, M. R. and Todd, E. C. D. 2007. Serving food safety. Consumer perceptions of food safety at restaurants. International Journal of Contemporary Hospitality Management 19(6): 476-484.

Larsen, M. H., Dalmasso, M., Ingmer, H., Langsrud, S., Malakauskas, M., Mader, A., ... and Jordan, K. 2014. Persistence of foodborne pathogens and their control in primary and secondary food production chains. Food Control 44: 92-109.

Little, C. and Sagoo, S. 2009. Evaluation of the hygiene of ready-to-eat food preparation areas and practices in mobile food vendors in the UK. International Journal Environmental Health Research 19(6): 431-443.

Lynch, R. A., Elledge, B. I., Griffith, C. C. and Boatright, D. J. 2003. A comparison of food safety knowledge among restaurant managers, by source of training and experience, in Oklahoma County, Oklahoma. Journal of Environmental Health 66: 9-14.

Maes, S., Heyndrickx, M., Vackier, T., Steenackers, H., Verplaetse, A. and De Reu, K. 2019. Identification and spoilage potential of the remaining dominant microbiota on food contact surfaces after cleaning and disinfection food industries. Journal of Food Protection 82(2): 262-275.

Marzano, M. A. and Balzaretti, C. M. 2011. Cook-serve method in mass catering establishments: Is it still appropriate to ensure a high level of microbiological quality and safety? Food Control 22(12): 1844-1850.

Medu, O., Turner, H., Cushon, J. A., Melis, D., Abdellatif, L. T. and Schwandt, M. 2016. Restaurant inspection frequency: The RestoFreq study. Canadian Journal of Public Health 107(6): e533-e537.

Ministry of Housing and Local Government (KPKT). 2014. Guidelines on food premises grading system in the local authority area, secretary general's circular of the ministry of local government development, No. 2 of 2014. Malaysia: KPKT.

Mohammed, A. M., Padhi, B. K., Shameel, M., Elkhalifa, A. M., Tahash, M., Chandramohan, S. and Hazazi, A. 2020. Assessment of foodborne illness awareness and preferred information sources among students in Saudi Arabia: A cross-sectional study. Food Control 112: 107085.

Mohd Nizam, L., Mohd Ferdaus, M. A., Roshita, I., Rozila, A. and Zaiton, H. 2014. Microbiological quality of food contact surface at selected food premises of Malaysian heritage food (‘Satar’) in Terengganu. The International Journal of Engineering and Science 3(9): 66-70.

Mohd Rejab, N. H., Ahmad Jazuli, N. N., Jamil, J., Arsat, A. and Hassan, H. 2015. Customer awareness and attitude towards restaurant grading system in Shah Alam. In Proceedings of the 2nd International Hospitality and Tourism Conference 2014, p. 397-400. Penang, Malaysia.

Ncube, F., Kanda, A., Chijokwe, M., Mabaya, G. and Nyamugure, T. 2020. Food safety knowledge, attitudes and practices of restaurant food handlers in a lower-middle-income country. Journal of Food Science and Nutrition 8: 1677-1687.

Nurul Shuhada, S., Farah Ayuni, S., Mohd Izwan, M. and Razi Ikwan, M. R. 2019. Microbial assessment of utensil and worktop surfaces at university food court. Health Scope 1: 157-160.

Phillips, C. A. 2016. Bacterial biofilms in food processing environments: A review of recent developments in chemical and biological control. International Journal of Food Science and Technology 51(8): 1731-1743.

Shafizi, A. W., Mohamad Ridzuan, M. S., Ubong, A., New, C. Y., Mohhidin, O., Toh, P. S., ... and Son, R. 2016. Assessing *Staphylococcus aureus* in ready-to-eat food and risk assessment of food premises in Putrajaya. International Food Research Journal 23(4): 1761-1766.

Siti Shahara, Z., Nur Hidayah, A. H. and Mazrura, S. 2018. Microbiological assessment of food contact surfaces in residential college cafeterias at a local university in Malaysia. Journal Sains Kesihatan Malaysia 16(2): 33-38.

Sneed, J., Strohbehn, C., Gilmore, S. A. and Mendonca, A. 2004. Microbiological evaluation of foodservice contact surfaces in Iowa assisted-living facilities. Journal of the American Dietetic Association 104(11): 1722-1724.

Takooree, S. D., Motah, U. D., Lobine, D., Ranghoo-Sanmukhiya, V. M. and Neetoo, A. H. 2019. Domestic chopping boards represent important vehicles of microbial food contamination and human pathogens. Journal of Safety and Hygiene 5(4): 202-205.

Uyttendaele, M., Franz, E. and Schlüter, O. 2015. Food safety, a global challenge. International Journal of Environmental Research and Public Health 13(1): 67.

Wahida, S., Mohd Nizam, L., Wan Zawiah, W. A., Tuan Zainazor, T. C. and Zaiton, H. 2017. A review on incidences of foodborne diseases and interventions for a better national food safety system in Malaysia. Malaysian Applied Biology 46(3): 1-7.