Risk Assessment Studies
Report No. 54

Microbiological Hazard Evaluation

MICROBIOLOGICAL QUALITY OF SUSHI AND SASHIMI IN HONG KONG (2014)

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EXECUTIVE SUMMARY

This study aims to assess the microbiological quality of sushi and sashimi available in the local market and to provide an overview on the pH value of acidified rice in sushi. This study also highlighted the potential microbiological risks associated with sushi and sashimi.

During July and October 2014, the Centre for Food Safety (CFS) obtained a total of 197 samples, including 98 sushi samples and 99 sashimi samples, from different licensed restaurants and retail outlets. Laboratory analysis for microbiological parameters, namely aerobic colony count (ACC), *Escherichia coli* count, *Salmonella* spp., *Staphylococcus aureus* count and *Vibrio parahaemolyticus* count were conducted by the Public Health Laboratory Services Branch of the Centre for Health Protection (CHP). Besides, *Bacillus cereus* count was also tested for sushi samples. At the same time, the pH values of the rice from sushi samples were analysed by the Food Research Laboratory (FRL) of the CFS.

Results showed that out of the 197 sushi and sashimi sampled, four samples (2.0%) were found to exceed the prevailing microbiological limits for hygienic quality, i.e. ACC and *E. coli*, set out in the Microbiological Guidelines for Food issued by the CFS in August 2014. They included a sea urchin sashimi, a prawn sashimi and a salmon roe sushi with ACC levels ranged from 2.0×10^7 to 3.0×10^7 cfu/g and a salmon sashimi with 200 cfu/g of *E. coli*. As for microbiological safety, no samples were found to contain excessive pathogenic bacteria, including *B. cereus*. Factors like the quality of raw materials, unhygienic handling, and/or inadequate temperature control, either alone

or in combination, may account for the above laboratory results for hygienic quality. In response, the CFS gave health advice to relevant premises. Except that the sea urchin sashimi was not available in follow-up visits, other follow-up samples taken were all satisfactory.

Separately, acidified rice is commonly used in sushi and proper acidification of rice to a pH value of 4.6 or below is known to inhibit the growth of pathogenic bacteria, particularly *B. cereus*. In this study, 96/98 (98.0%) of rice portion of sushi were found to have a pH value of 4.6 or below. Two samples had a pH value of 4.7. Also, among the responded vendors, none of them practiced the verification of sushi rice acidification. To ensure adequate vinegar in sushi rice, food handlers are recommended to check its pH of acidified rice from time to time, especially when there is new staff or recipe. In addition, finished sushi should therefore be kept at temperature at 4°C or below or, discard 4 hours after being displayed at above 4°C.

Conclusion

Of the sushi and sashimi examined, four samples were considered to be unsatisfactory hygienically but there was no food safety concern from microbiological perspective.

While vast majority of rice from sushi examined in this study was generally acidified to the recommended level of pH 4.6 or below (which may allow the sushi to be displayed at room temperature for short periods of time), responded traders were not commonly found to measure the pH of acidified sushi rice.

Members of the trade should take note of the results of this study and adopt appropriate measures for hygienic handling and safe display of sushi and sashimi.

Advice to public

- Before ordering sashimi and sushi in restaurants, check whether the premises have a Food and Environmental Hygiene Department (FEHD) licence and have the endorsement for sale of sashimi and sushi.
- Check if sashimi and sushi are fresh and kept under suitable temperature at time of consumption.
- Consume takeaway sushi and sashimi as soon as possible.
- People with weakened immunity, elderly, pregnant women and young children are at higher risk for foodborne illness; they should avoid raw or partially cooked food.

Advice to trade

- Buy raw materials from reliable and hygienic suppliers.
- Imported raw oyster, meat to be eaten raw and raw materials for the preparation of sushi or sashimi should be accompanied with valid and recognised official health certificates.
- Food eaten raw inside display refrigerator should be properly wrapped up by clean, non-toxic materials or stored in covered containers and should bear a food label with expiry date.
- The temperature of display refrigerator should be closely monitored and temperature log record should be maintained.
- Rice should be properly acidified to a pH of 4.6 or below. Acidification of rice should occur as soon as it is cooked.
- Ideally, prepared sushi should be kept at temperature at 4°C or below.

However, if sushi is to be displayed at temperature higher than 4°C, a documented time control system should be in place to ensure that sushi is not displayed for prolonged periods of time. As a general rule, if properly handled sushi with rice acidified to pH 4.6 or below have been displayed at an environment higher than 4°C:

- for less than 2 hours, they can be refrigerated for final use later or used before the 4 hours limit is up.
- for more than 2 hours but less than 4 hours, they should be used before the 4 hours limit is up but should not be returned to the refrigerator.
- for more than 4 hours, they should be discarded.

- Sushi should be kept refrigerated unless it is being displayed and appropriate measures should be adopted to ensure "first-in-first-serve" of prepared sushi e.g. use date and time coding to show the storage time.
- Keep displayed sushi out of direct sunlight which may increase the storage temperature.
- Keep displayed sashimi, except for live bivalve molluscs intended for raw consumption, at temperature at 4°C or below.
- Live bivalve molluscs intended for raw consumption should not be subjected to extreme temperatures. In most cases, storage above 10 ℃ (including at room temperature) or below 2 ℃ should be avoided.

Microbiological Quality of Sushi and Sashimi in Hong Kong (2014)

OBJECTIVES

The purposes of the study are to assess the microbiological quality of sushi and sashimi available in the local market and to provide an overview on the pH value of acidified rice in sushi.

INTRODUCTION

2. Sushi and sashimi are becoming increasingly popular in the local market and there are different ways of serving, e.g. preparing immediately upon ordering, displaying on conveyor belts, displaying in packaged form for takeaway, etc. Uncooked seafood, especially fish slices, is a common ingredient in sushi and sashimi and may contain harmful microorganisms if they are originated from contaminated waters. Besides, sushi prepared with cooked ingredients is often prepared alongside with sushi made with other raw ingredients including fresh vegetable ingredients, which may increase the risk of cross contamination of cooked products. Since the preparation of sushi and sashimi involves minimal heat treatment and manual handling is usually required, very often they are considered as high-risk food items.

3. Locally, sushi and sashimi are classified as restricted food in the

Food Business Regulation (Chapter 132X) under the Public Health and Municipal Services Ordinance. In particular, "sashimi" is defined as food consisting of fillets of marine fish, molluscs, crustaceans, fish roe or other seafood to be eaten in its raw state. Under the same Regulation, "sushi" refers to food consisting of cooked and pressed rice flavoured with vinegar and garnished with other food ingredients including raw or cooked or vinegared seafood, marine fish or shellfish roe, vegetable, cooked meat or egg on top or in the middle which may or may not be wrapped with seaweed and usually served in pieces.[1] With the increase in variety of delicacy, sushi garnished with raw meat like raw beef is also available in our locality.

4. Relevant endorsement(s) should be obtained for sale of sushi, sashimi, oysters to be eaten in raw state, meat to be eaten in raw state in general restaurants, factory canteens and food factories. A restricted food permit is required for only selling these food items for consumption off the premises and the food has to be supplied from a source approved by Food and Environmental Hygiene Department (FEHD). Additional license or endorsement is required for other types of food business.[i] The licensing requirements and conditions provide requirements on transportation, storage, stock record, hygienic handling and preparation of raw materials and the restricted food for sale. However, local media reported that some small-sized premises displayed sushi and sashimi for takeaway in open reach-in display refrigerators that may not be able to maintain a low temperature for storage of these products. In such cases,

[i] As for Fresh Provision Shop licences, licensees who prepare, handle and sell "sashimi", "sushi", "oyster to be eaten in its raw state" and "meat to be eaten in its raw state" as a take-away service coupled with retail sale of other chilled/frozen commodities are required to obtain a food factory licence in addition to the Fresh Provision Shop licence, whereas licensees who carry on the retail sale of chilled/frozen commodities in addition to the sale of "sashimi", "sushi", "oyster to be eaten in its raw state" and "meat to be eaten in its raw state" without preparation or handling are required to obtain FEHD's permission for sale of these food items to be endorsed on their Fresh Provision Shop licences.

vendors may have violated relevant licensing conditions.[2]

5. Despite the requirements on hygienic practices are in place, sporadic food poisoning outbreaks related to the consumption of sushi and sashimi occurred in Hong Kong, which can reflect the inherent risk associated with consumption of raw food ingredients. From 2009 to October 2014, among the 395 confirmed food poisoning outbreaks [ii] recorded by the CHP, sushi or sashimi were implicated in 36 cases as one of the suspected incriminated food items. Pathogenic microorganisms such as *Salmonella* spp. and *Vibrio parahaemolyticus* were detected in majority of these outbreaks.

6. Previously, local studies were conducted to assess the microbiological quality of sushi and sashimi. In 2000, the FEHD conducted a risk assessment study on sushi and sashimi in Hong Kong.[1] The study analysed 1020 sushi and 906 sashimi samples tested under the Food Surveillance Programme from 1997 through 1999, in which 13.8% of sushi and 11.1% of sashimi were found unsatisfactory in terms of their hygienic quality and 0.26% of all samples yielded specific pathogens, such as *Staphylococcus aureus*, *V. parahaemolyticus* and *Listeria monocytogenes*. In 2008, a joint Centre for Food Safety (CFS) and Consumer Council study on the Microbiological Quality of Rice and Noodles in Hong Kong also analysed the microbiological quality of sushi available in the local market.[3] Out of 19 sushi samples tested, three (15.8%) were found to contain excessive aerobic colony count (ACC)

[ii] Food poisoning outbreak: An incident in which two or more persons experience a similar illness after ingestion of a common food, and epidemiological analysis implicates the food as the source of the illness. (Exception: one person having chemical poisoning or biochemical poisoning constitutes an outbreak.)
Confirmed outbreak: A clinically and epidemiologically compatible illness with EITHER

- Laboratory criteria of causative agent; OR
- Epidemiological linkage to another confirmed outbreak

and/or *S. aureus*. Though the samples did not have imminent health concern, the result reflected that there was room for improvement on the microbiological quality of these types of food items. As such, an update overview on the quality of sushi and sashimi is required to examine the current situation.

7. Separately, during sushi preparation, vinegar is added to sushi rice when it is warm to produce an acidic environment discourages the growth of pathogenic microorganisms. With proper acidification control, i.e. to a pH less than or equal to 4.6, rice helps to inhibit the growth of pathogens like *Bacillus cereus*. Some authorities also recommend the measurement of pH of sushi rice before using it for making sushi.[4,5]

8. Nevertheless, the study conducted in 2000 did not take into account the reduction of risk by proper acidification of sushi rice with vinegar. To have better understanding the pH values of rice from sushi, a follow-up risk assessment study was conducted by the CFS in 2014 to assess the microbiological quality of sushi and sashimi.

SCOPE OF STUDY

9. Due to the diversity of sushi and sashimi available in the local market, this study primarily focused on the products which may be of higher microbiological risk. The samples were selected on the basis of past food surveillance results and suspected incriminated food in the previously reported food poisoning cases. Additionally, some potentially high risk food items such as Thai-style shrimp sashimi and raw beef were included.

10. For sushi, the samples were grouped into two types: (1) sushi or sushi roll and (2) hand roll.

11. For sashimi, there were three main types including (1) fish, (2) bivalve shellfish, and (3) other raw ingredients such as shrimp, octopus, sea urchin, beef, etc.

METHODOLOGY

Sampling

12. The sampling was conducted from July to October 2014 and was carried out by health inspector of the FEHD.

13. A total of 197 samples were collected, which included 98 sushi samples and 99 sashimi samples. Samples in the following format were included in the sampling plan:-

Dine-in restaurant

- Served upon ordering;
- Displayed on conveyor belts;
- Displayed on buffet tables;

Takeaway or home delivery services

- Displayed for takeaway only, including those sold in supermarkets but excluding those ordered by telephone or other electronic means; and
- Home delivery service, i.e. ordered by telephone or other electronic means.

14. The distribution of collected samples among these categories is outlined in Table 1.

Table 1: Sampling distribution

Types of premise	Displayed or served forms	No. of Samples taken		Total
		Sushi	Sashimi	
Dine-in restaurants	Served upon ordering	37	39	76
	Displayed on conveyor belts	7	5	12
	Displayed on buffet tables	17	16	33
Takeaway shops	Displayed for takeaway	35	37	72
Home delivery service	Served upon ordering	2	2	4
	Total:	98	99	197

15. Health inspectors were required to jot down the main ingredients and external product temperatures of the samples. Food premises were selected by the responsible health inspectors and the following guiding principle had been employed during sampling exercise as far as possible:

(i) take samples from different districts within Hong Kong, Kowloon, and New Territories;

(ii) avoid sampling at different outlets belonging to the same retail chain; and

(iii) avoid taking more than one sample from any outlet.

16. However, considering some chains may have different shops serving sushi and sashimi in different serving forms, it was allowed to collect different serving forms under the same chain. Similarly, there are limited premises provide home delivery services for sushi and sashimi, one sushi and one sashimi samples were allowed to be ordered from the

same premise.

17. For sushi samples, an additional set of corresponding sushi samples was dispatched to the Food Research Laboratory (FRL) to analyse the pH value of the rice with other ingredients removed from the sushi.

Laboratory analysis

18. All samples were stored at 4°C or below during transport and they were delivered to the Public Health Laboratory Services Branch of the CHP, Department of Health, and the FRL, within four hours after sampling. Food ingredients that were added as garnishes, such as leaves and shredded turnip, were removed from the samples before microbiological analysis. ACC, *Escherichia coli* count, presence or absence of *Salmonella* spp. in 25 g sample, *S. aureus* count and *V. parahaemolyticus* count were used to reflect the microbiological quality of sushi and sashimi. For sushi samples, *B. cereus* count was also conducted on top of the foresaid parameters for sashimi.

19. The enumeration of ACC in samples was performed according to Public Health England (2014) Food, Water & Environmental Microbiology Standard Method FNES14 [F10] version 3 (Spiral Plate Method at 30^{o}C). *E. coli* count in samples was performed using the AOAC Official Methods 991.14 (Revised: March 1998) (Petrifilm Method). The enumeration of *V. parahaemolyticus* was conducted according to PHLSB in-house method or Health Products and Food Branch, Ottawa (2004) Method MFLP-37, Part 1. The enumeration of *B. cereus*, and the detection of *Salmonella* spp. were performed respectively

according to National Standard Method F15 issue 1 and F13 issue 1 published by Health Protection Agency in the U.K. *S. aureus* (coagulase-positive staphylococci) counts were enumerated according to Health Products and Food Branch, Ottawa (2004) Method MFLP-21 or ISO 6888-2:1999.[6]

20. The pH value of the rice from sushi was measured by an in-house single laboratory validated method. In brief, the rice from each individual sushi of the same sample was taken out and mould them into a ball. Due care was exercised to avoid contact with wasabi, sauce, sashimi or other components of the sushi. A calibrated portable pH meter was used to measure the pH value by inserting the probe deeply into the rice ball. The probe was then thoroughly rinsed with deionised water and dried between measurements. Three measurements were taken at different locations of the rice ball and an average was reported as the pH result.

Result analysis

21. Results of the samples were analysed by the Risk Assessment Section of the CFS. The hygienic quality and microbiological safety were assessed in accordance with the Microbiological Guidelines for Food (the Guideline).[7]

Hygienic quality - ACC and E. coli

22. ACC is the total number of bacteria found in food. It includes those naturally occurring and those as a result of contamination. ACC is an indicator of quality but not safety. The level of ACC in food depends

on the type and duration of processing that the food has received during production as well as how the food is handled and stored thereafter.[8]

23. However, ACC is not applicable to fresh fruit or vegetables, where raw vegetables are expected to contain microorganisms present from the environment; ACC is likely to be high. As such, this criterion is not applied to sushi samples containing fresh fruit or vegetable ingredients.[7]

24. *E. coli* is a bacterium commonly found in the gastrointestinal tract of humans and warm-blooded animals. It is commonly used as an indicator organism to reflect the hygienic quality of food. Its presence in food generally indicates direct or indirect faecal contamination. In general, substantial number of the bacterium in food suggests a general lack of cleanliness in handling and improper storage.[7]

25. The ACC and *E. coli* results were assessed against the criteria listed in Table 2. These criteria were extracted from the Guidelines. For the purpose of this study, sushi and sashimi samples were grouped in one of the five categories for ACC assessment as detailed in Table 2. Sushi in the market contains different ingredients and these ingredients may have different preparation methods; for the purpose of this study, the categorisation for ACC assessment was primarily based on the ingredients and the information collected by health inspectors.

Table 2. ACC and *E. coli* criteria used in this study

	Microbiological quality Result (colony-forming unit (cfu/g))		
	Satisfactory	Borderline	Unsatisfactory
ACC [30°C /48 hours]			

	Microbiological quality Result (colony-forming unit (cfu/g))		
	Satisfactory	Borderline	Unsatisfactory
● Food category 5. Cooked foods chilled but with some handling prior to sale or consumption †	$<10^5$	10^5-$<10^7$	$\geq 10^7$
● Food category 7. Food mixed with dressings, dips, pastes † ● Food category 9. Raw ready-to-eat meat and fish, cold smoked fish ‡	$<10^6$	10^6-$<10^7$	$\geq 10^7$
● Food category 10. Preserved food products – pickled, marinated or salted§ ● Food category 12. Fresh fruit and vegetables, products containing raw vegetables§	N/A	N/A	N/A
Hygiene indicator organisms			
E. coli	<20	20 - $\leq 10^2$	$>10^2$

N/A= not applicable

Categorisation when assessing the ACC results for the purpose of this study -

† Sushi samples containing only cooked ingredients were grouped under Food category 5, while those contained dressings such as salad were grouped under Food category 7. Cooked surf clam was also grouped under Food category 5.

‡ Sashimi (including raw beef) and sushi samples containing sashimi ingredients (including fish roe and roe-like ingredients) or seared ingredients were grouped under Food category 9.

§ Sushi samples containing preserved food and raw vegetables were grouped under Food categories 10 and 12 respectively where ACC assessment is not applicable

26. The sashimi samples of live and raw bivalve molluscs were assessed as other ready-to-eat food for the *E. coli* criterion in Table 2, even there is specific *E. coli* criterion stipulated in the Guidelines for live and raw bivalve molluscs intended for direct consumption. It is because the Guidelines as well as the testing method for the *E. coli* criterion were not adopted when the sampling for this study started.

Microbiological safety - Pathogens

27. *Salmonella* spp., *V. parahaemolyticus* and *S. aureus* are pathogenic bacteria that may cause food poisoning. They are among the common food poisoning microorganisms in Hong Kong and hence were used to evaluate the safety of sushi and sashimi in this study.

28. Emetic food poisoning caused by *B. cereus* is often associated with starchy food such as rice, especially when rice is kept improperly under room temperature for a prolonged period of time.[9] *B. cereus* was included as an additional parameter for sushi samples for this study.

29. The pathogen results were assessed against the criteria listed in Table 3. These criteria were extracted from the Guidelines.

Table 3. Pathogen criteria used in this study

Criterion	**Result (cfu/g unless otherwise specified)**		
	Satisfactory	**Borderline**	**Unsatisfactory:** potentially injurious to health and/or unfit for human consumption
Salmonella spp.	Not detected in 25g	N/A	Detected in 25g
V. parahaemolyticus	< 20	20 - $\leq 10^3$	> 10^3
S. aureus and other coagulase-positive staphylococci	< 20	20 - $\leq 10^4$	> 10^4
B. cereus	< 10^3	10^3 - $\leq 10^5$	> 10^5

Remark: In general, the limits of "Satisfactory" are also the detection limits for respective pathogens.

RESULTS

Overall microbiological results

30. For hygienic quality, the ACC and *E. coli* results of the sushi and sashimi are presented in Tables 4 and 5 respectively. Out of the 182 samples where ACC assessment applies, three samples, a sea urchin sashimi, a prawn sashimi, and a salmon roe sushi were of unsatisfactory quality. The ACC in these samples ranged from $2.0 \times 10^7 – 3.0 \times 10^7$ cfu/g (Table 4). On the other hand, one salmon sashimi was of unsatisfactory quality due to the presence of 200 cfu/g of *E. coli* (Table 5).

Table 4. ACC results of sushi and sashimi (Number of applicable samples=182)

	Microbiological results (cfu/g)					
	$<10^3$	10^3-$<10^4$	10^4-$<10^5$	10^5-$<10^6$	10^6-$<10^7$	$\geq 10^7$
Microbiological quality (Food category 5)	**Satisfactory**			**Borderline**		**Unsatisfactory**
Sushi samples containing only cooked ingredients (n=33)	6	9	3	7	8	0
Sashimi (Surf clam only) † (n=11)	1	2	2	5	1	0
Microbiological quality (Food categories 7 and 9)	**Satisfactory**				**Borderline**	**Unsatisfactory**
Sashimi (including raw beef) (n=88)	9	14	20	34	9	2
Sushi samples containing sashimi ingredients or dressings (n=50)	4	7	15	19	4	1

† Surf clam is usually cooked for serving, which is characterised by the red colour on the tip side after cooking. As it is usually presented as sashimi, it was also grouped as a type of sashimi for the purpose of this study.

Table 5. *E.coli* results of sushi and sashimi (n=197)

	Microbiological results (cfu/g)		
	Satisfactory	Borderline	Unsatisfactory
	<20	20 - $\leq 10^2$	$>10^2$
Sushi (n=98)	97	1	0
Sashimi (n=99)	97	1	1

31. For microbiological safety, the *V. parahaemolyticus* and *S. aureus* results of sashimi and the *V. parahaemolyticus*, *S. aureus* and *B. cereus* results of sushi are presented in Tables 6 and 7 respectively. No samples were detected with *Salmonella* spp. In addition, no pathogenic bacteria, including *B. cereus*, were found to present in excessive levels that are potentially injurious to health. It appeared that more sashimi samples were found to contain *S. aureus* and other coagulase-positive staphylococci in comparison with sushi samples.

Table 6. Pathogen results of sashimi (n=99)

Criteria	Microbiological results					
	cfu per g					
	<20	20-$\leq 10^2$	$>10^2$-$\leq 10^3$	$>10^3$-$\leq 10^4$	$>10^4$-$\leq 10^5$	$>10^5$
V. parahaemolyticus	97	2	0	0	0	0
S. aureus and other coagulase-positive staphylococci	90	9	0	0	0	0

Table 7. Pathogen results of sushi (n=98)

Criteria	Microbiological results					
	cfu per g					
	<20	20-$\leq 10^2$	$>10^2$-$\leq 10^3$	$>10^3$-$\leq 10^4$	$>10^4$-$\leq 10^5$	$>10^5$
V. parahaemolyticus	98	0	0	0	0	0
S. aureus and other coagulase-positive staphylococci	97	1	0	0	0	0
B. cereus	98			0	0	0

32. In summary, four samples were found to exceed the

microbiological limits set out in the Guidelines, in which three had excessive levels of ACC and one had excessive level of *E. coli*. The hygienic quality of these samples needed further improvement while they were not harmful for consumption. The microbiological classes with respect to each criterion are summarised in Table 8.

Table 8. Number of sushi and sashimi samples in each of the microbiological quality class, classified in accordance with the Guidelines

	Satisfactory	Borderline	Unsatisfactory	Unsatisfactory: potentially injurious to health and/or unfit for human consumption
ACC (applicable to 182 samples)	145 (79.7%)	34 (18.7%)	3 (1.6%)	N/A
E. coli	194 (98.5%)	2 (1.0%)	1 (0.5%)	N/A
V. parahaemolyticus	195 (99.0%)	2 (1.0%)	N/A	0
S. aureus and other coagulase-positive staphylococci	187 (94.9%)	10 (5.1%)	N/A	0
Salmonella spp.	197 (100%)	N/A	N/A	0
B. cereus (n=98; only sushi samples were tested)	98 (100%)	0	0	0

N/A = "Not applicable"

pH values of sushi rice

33. Results showed that 96/98 (98.0%) rice from sushi had a pH value of less than or equal to 4.6. Two samples had pH of 4.7.

Survey responses on the handling practice

34. In this study, the practice of (i) verification of pH of acidified rice and (ii) provision of ice pack or ice cube for takeaway had been asked by health inspectors during sampling. According to the result of this survey, none of the responded vendors (n=194) said they would verify the pH of rice after acidification. On the other hand, only 11/153 (7.2%) respondents provided ice pack or ice cube for takeaway.

35. For samples collected from the takeaway shops, 14/72 (19.4%) samples were found to have an external temperature higher than 4°C, with these samples having an average temperature of 7.0°C and a maximum temperature of 17°C.

DISCUSSION

Microbiological quality of local sushi and sashimi

36. Among the samples collected in the study, the microbiological quality of local sushi and sashimi were generally satisfactory except few samples with potential hygienic issues. Two sashimi and one sushi samples were found to contain excessive levels of ACC, which indicated unsatisfactory hygienic quality. One salmon sashimi sample was found containing excessive level of *E. coli* which suggests direct or indirect faecal contamination. Factors like the quality of raw materials, unhygienic handling, and/or inadequate temperature control, either alone or in combination, may result in the unsatisfactory microbiological quality of the sushi and sashimi samples. Vendors of these unsatisfactory samples were reminded to review and improve the food handling practices among their staff.

37. *S. aureus* was not found in excessive levels in sushi and sashimi in this study, but more sashimi samples were found to contain higher levels of *S. aureus* in comparison with sushi samples. The bacterium usually contaminates food by contact with food handlers' hands. Although both sushi and sashimi usually involve manual handling, sashimi samples collected in this study appeared to be high risk of contamination with *S. aureus*. Unlikely sushi rice that usually acidified with vinegar, temperature abuse will facilitate the growth of *S. aureus* in sashimi and subsequent production of enterotoxins. According to the U.S. Food and Drug Administration, the implicated food usually were not kept at a refrigerated temperature of <10℃ for cold holding in cases of human intoxication.[10]

38. Detailed comparison with the previous risk assessment study was not performed as the microbiological limits of hygiene quality parameters were different from those adopted in the previous issue of the Guidelines. In the latest Guidelines, factors like the raw ingredients used, the nature and degree of processing before sale were taken into account during categorisation of food.[7] It is worthwhile to note that while no excessive levels of pathogens were found in the current study, 2 out of 1020 sushi samples were found with *S. aureus*, and 3 out of 906 sashimi samples were found with *V. parahaemolyticus* and *L. monocytogenes* in a previous study.[1] Yet, it should be noted that the sample size is limited in the current study.

39. Despite the results that none of the microbiological quality of sushi and sashimi collected in this study were found unsatisfactory in terms of pathogens, these products are of higher risk where raw ingredients are used and manual handling procedures are involved.

Indeed, a shrimp sashimi sample taken at a Thai restaurant under CFS' routine food surveillance programme during the study period (not part in this study) were found contaminated with *Salmonella*.[11] Nevertheless, all two Thai-style shrimp sashimi samples collected for this study were satisfactory. This shows that limited samples size (and hence limited varieties of sushi and sashimi) may have precluded the ability to detect unsatisfactory sample. Consumers should aware of the inherent risk of consuming raw or partially cooked food, and should only patronise licensed food premises with specific endorsement for manufacturing and sale of sushi and sashimi.

40. On the other hand, food handlers should observe the hygiene practice for preparing and selling sushi and sashimi. Separate portions of the restaurants, factory canteen and food factories should be designated for preparing sashimi and sushi, separate sets of equipment with label to indicate their designated use should be used for such purpose to ensure there is no cross-contamination between sushi/sashimi and other foods or environmental contamination. Food handlers are required to wear clean protective clothing including head coverings. They should handle the food properly and cleanse or sterilise the tools properly. Food to be eaten in its raw state must be kept separately. Frozen raw materials for the preparation of sushi/sashimi shall be stored at a temperature below -18℃ in separate, or designated part of a freezer to avoid cross-contamination. A separate or designated portion of a refrigerator shall be provided for the storage of defrosted raw materials for the preparation of sushi/sashimi under 4°C. Any sushi/sashimi food with slimy surface, in dripping state or of dull colour must be immediately discarded. These measures can reduce the risk of food poisoning due to consumption of sushi/sashimi and they are some of the licensing

requirements/conditions for the food premises with endorsement for preparing, handling and selling sashimi and sushi.

41. As for consumers, people with weakened immunity, elderly, pregnant women and young children are at higher risk for foodborne illness; they should avoid eat raw or partially cooked food, including sushi and sashimi.

Bacillus cereus and pH of sushi rice

42. *B. cereus* is a spore-forming bacterium and ubiquitous in the environment. *B. cereus* is readily isolated from soil, cereal crops, and vegetables, etc. but the level is generally too low to cause food poisoning. However, cooking can give a chance for it to grow into large numbers when opportunity arises. Not only the spores can survive normal cooking temperatures, the heat of cooking also activates the germination of spores of *B. cereus* to become vegetative cells. Cooking also kills other bacteria that are not heat-resistant resulting in an environment short of competitors for the vegetative cells of *B. cereus* to grow. If such cooked food is left at ambient temperatures for a prolonged period, the vegetative cells can multiply into large numbers and/or eventually produce emetic (cause vomiting) toxin.[12,13] Hence, outbreak associated with vomiting have been most commonly associated with cooked rice held at ambient room temperature before reheating.[14]

43. There were overseas studies reporting the identification of excessive levels of *B. cereus* in sushi rice. In a survey of 89 retail sushi outlets across four territories of Australia conducted in 2006/2007 by the NSW Food Authority, 6 out of 851 (0.71%) sushi samples were

categorised as potentially hazardous due to elevated levels of *B. cereus*, where the level of *B. cereus* $\geq 10^4$ was considered as potentially hazardous. Among these 6 samples, 5 were collected from a single outlet. Acidified rice samples were also collected, in which 1 sample was considered as unsatisfactory due to high standard plate count and around 15% of acidified rice samples had a pH value greater than 4.6.[15] In addition, it was found that cooling of cooked rice was often uncontrolled and verification of the pH of sushi rice after acidification was rarely undertaken, and rice with a higher pH than the 4.6 limit were sometimes identified. In conjunction with the survey, the NSW Food Authority published Food Safety Guidelines for the Preparation and Display of Sushi which has included the ways to measure the pH value of acidified rice. Subsequent survey in 2009 showed an apparent improvement in comparison with the previous survey, and none of samples taken were found to be of potentially hazardous and only one sample (7%) was classified unacceptable due to the pH being greater than 4.6.[16]

44. Sushi samples collected in this study were not found to contain high levels of *B. cereus* and the pH values of the rice portions were generally equal to or below the recommended level of pH 4.6 that can inhibit the growth of *B. cereus*. This high compliance rate may due to the use of freshly prepared sushi rice and/or proper acidification and cooling of sushi rice. It was noted that food handlers generally prepare acidified rice by mixing a fixed ratio of rice and vinegar, and that seems to be a way of proper acidification on the basis of available results.

45. Having said that, it is still recommended to measure the pH of acidified rice from time to time, especially for new staff and for the use of

new recipe, to ensure achieving pH values of 4.6 or below. This can be done by using pH paper/strips or pH metre.[4]

Sushi and sashimi kept in open reach-in display refrigerators

46. There were media reports pointing out that some sushi for takeaway only are kept in open reach-in display refrigerators that may not be able to maintain a low temperature for sushi storage. In this study, 19.4% samples collected from takeaway shops were found to have external product temperature over 4°C which can allow the growth of microorganisms. In general, sushi and sashimi should be kept at safe temperature i.e. at or below 4℃. Noting that pH values of sushi rice in the local market are generally equal to or below the recommended level of 4.6, it is considered that sushi could be kept at room temperature provided that there is appropriate time control measures in place to limit the display time. The NSW Food Authority conducted modelling of food poisoning bacteria to assess the safety of sushi displayed at unrefrigerated condition. The study concluded that the product with proper acidification of rice (i.e. to pH ≤4.6) would need to be displayed at 25℃ or higher for more than four hours for pathogenic bacteria to reach dangerous levels.[4] That said, sashimi should not be displayed at room temperature because its preparation normally does not involve acidification. In addition, sashimi ingredients placed on top of sushi are generally not acidified and may even increase the pH of the finished sushi.

47. Although some serving forms have sushi and sashimi displayed at room temperature such as serving on self-service conveyor belt in general restaurants, all sushi/sashimi must be properly covered and

protected from risk of contamination when displayed. In addition, there is licensing condition that any prolonged display of sushi or sashimi on a conveyor belt shall be avoided.

48. The temperature of open reach-in display refrigerators may not effectively chill prepared sushi or sashimi at or below 4℃. Prepared sushi/sashimi should be placed under refrigeration in a separate or designated portion of a refrigerator at or below 4℃ unless it is being displayed for sale immediately. All sushi/sashimi shall be properly wrapped up by a layer of non-toxic plastic material or stored in covered containers when displayed inside a refrigerator. The vendors should avoid prolong display of these products by labelling with the date before which the sushi/sashimi shall be consumed. Freshness of sushi/sashimi must be maintained at all times. Any sushi/sashimi with slimy surface, in dripping state or of dull colour must be immediately discarded. Vendors should also advise consumers to consume the products as soon as possible or store them in a refrigerator for later consumption before the date which the sushi/sashimi shall be consumed.

Follow-up on the unsatisfactory samples

49. In this study, 4 samples were of unsatisfactory quality which needs improvement in microbiological quality. The CFS gave health advice to relevant parties and took follow-up samples, where available. No unsatisfactory results were found for the follow-up samples, while one sample was not found in follow-up visits.

Limitations

50. In this study, less than 200 samples were taken and because of wide variety of sushi and sashimi available on the market, only selected types were covered due to limited sample size.

51. Collected samples were categorised based on ingredients and information given to the health inspectors. It should be noted that the food production process and the ingredients may vary among food producers.

CONCLUSION AND RECOMMENDATIONS

52. This study showed that none of the sushi and sashimi samples were found to have microbiological food safety concern, and the pH values of sushi rice are generally equal to or below 4.6. Of the sushi and sashimi examined, four samples (2%) were considered to be unsatisfactory hygienically but there was no food safety concern from microbiological perspectives. Factors like the quality of raw materials, unhygienic handling, and/or inadequate temperature control, either alone or in combination, may result in the unsatisfactory microbiological quality of these sushi and sashimi samples. Although none of the vendors responded that they had measured the pH of acidified rice, sushi samples collected in the current study did not find to contain high levels of *B. cereus* and the pH values were generally equal to or below the recommended level of 4.6 that can inhibit the growth of *B. cereus*.

53. Below are some advices for public and trade in relation to sushi and sashimi

<u>Advice to Public</u>

- Before ordering sashimi and sushi in restaurants, check whether the premises have a Food and Environmental Hygiene Department (FEHD) licence and have the endorsement for sale of sashimi and sushi.
- Check if sashimi and sushi are fresh and kept under suitable temperature at time of consumption.
- Consume takeaway sushi and sashimi as soon as possible.
- People with weakened immunity, elderly, pregnant women and young children are at higher risk for foodborne illness; they should avoid raw or partially cooked food.

Advice to Trade

Purchase and Receiving

- Buy raw materials from reliable and hygienic suppliers. The production of seafood in some countries is in accordance with Hazard Analysis and Critical Control Point (HACCP) criteria, which helps to ensure food safety.
- Raw materials should be fresh, wholesome and of good quality. Quality check should be conducted at the time of receiving, e.g. frozen raw materials are still in a frozen state. Parasites like roundworms and tapeworms in fish can generally be killed by freezing it at -20°C for 24 hours.
- Imported raw oyster, meat to be eaten raw and raw materials for the preparation of sushi/sashimi should be accompanied with valid and recognised official health certificates.

Transportation

- Store raw materials and food eaten raw in an independent, clean and hygienic environment during transportation to avoid cross-contamination. Keep chilled food at a temperature between 0°C and 4°C and frozen food at -18°C or below.

Storage

- Store the food eaten raw in designated refrigerators or separate compartments of the refrigerator to avoid cross-contamination. Keep chilled food at a temperature between 0°C and 4°C and frozen food at -18°C or below.
- The temperature of freezer and fridge should be closely monitored and temperature log record should be maintained.
- Raw ingredients and food eaten raw should be stored separately to prevent cross-contamination.
- Label the storage time of the food and check it regularly.

- Adopt the "first-in-first-out" principle for storage. Do not use food beyond its expiry date or expected shelf life.
- Keep separate stock record for the food eaten raw and its raw materials to monitor their rotation.
- Avoid overstocking of food and its ingredients.
- Don't overstuff the refrigerator

Preparation

- Designate a separate area in a food room and use designated knives and chopping boards for handling the food eaten raw.
- Defrost frozen raw materials in refrigerators kept at a temperature between 0°C and 4°C and maintain it at this temperature before handling. Defrosted food should be handled and served to customers for consumption as soon as possible. Avoid re-freezing and re-defrosting.
- Food eaten raw such as marine products should be washed in designated sink thoroughly to prevent cross-contamination.

Cooling and holding (for sushi rice)

- Cool cooked rice from 60°C to 20°C as quickly as possible (within 2 hours); and from 20°C to 4°C, within 4 hours or less.
- Speed up the cooling process by using wide, shallow containers or reducing the size of the portions.
- Adopt appropriate measures to ensure "first-in-first-serve" of cooked rice e.g. use date and time coding to show the storage time.
- Rice should be properly acidified to a pH of 4.6 or below. Acidification of rice should occur as soon as it is cooked.
- Trade is recommended to check the pH of acidified rice regularly, especially when there is new staff or new recipe.

Display and Sale

- Food eaten raw placed inside display refrigerator should be properly wrapped up by clean, non-toxic materials or stored in covered containers and should bear a food label with expiry date.
- The temperature of display refrigerator should be closely monitored and temperature log record should be maintained.
- Cold food should be put in shallow utensils in a container with ice-cubes to keep the food in a chill state when serving to customers.
- Cold food in self-service counter should be put in shallow utensils in a container with ice-cubes to keep the food in a chill state. After thawing out of the ice, new ice-cubes should be refilled with water discarded.

- Food in self-serve conveyor belt or self-service counter should be properly covered.
- Provide sufficient number of tongs with long handle at self-serve counter for customers. Replace the tongs regularly. Remove contaminated tongs from the counter immediately.
- Supervise the self-serve counter area by appropriately trained staff to protect the food against contamination.
- Ideally, prepared sushi should be kept at temperature at 4°C or below. However, if sushi is to be displayed at temperature higher than 4°C, a documented time control system should be in place to ensure that sushi is not displayed for prolonged periods of time. As a general rule, if properly handled sushi with rice acidified to pH 4.6 or below have been displayed at temperature higher than 4°C:
  - for less than 2 hours, they can be refrigerated for final use later or used before the 4 hours limit is up.
  - for more than 2 hours but less than 4 hours, they should be used before the 4 hours limit is up but should not be returned to the refrigerator.
  - for more than 4 hours, they should be discarded.
- Sushi should be kept refrigerated unless it is being displayed and appropriate measures should be adopted to ensure "first-in-first-serve" of prepared sushi e.g. use date and time coding to show the storage time.
- Keep displayed sushi out of direct sunlight which may increase the storage temperature.
- Keep displayed sashimi, except for live bivalve molluscs intended for raw consumption, at temperature at 4°C or below.
- Live bivalve molluscs intended for raw consumption should not be subjected to extreme temperatures. In most cases, storage above 10 ℃ (including at room temperature) or below 2 ℃ should be avoided.

Cleanliness of Utensils

- Utensils should be thoroughly cleansed and sterilized by using a bactericidal agent approved by the Director of FEHD before and after use. Use clean and sterilized towel for wiping utensils.
- All knives used for the preparation of sushi/sashimi and meat to be eaten raw shall be placed or stored under cover in the knife sterilisation apparatus and immersed in the sterilisation solution in the steriliser when they are not in use.
- The sterilisation apparatus for the knife for preparation of sushi/sashimi and meat to be eaten raw shall be cleansed and the

sterilisation solution shall be renewed at least once daily.

Personal Hygiene

- All food handlers shall wear clean protective clothing and head coverings during food handling. If clothes become soiled during food preparation, change or clean them as necessary.
- Food handlers are advised to wear masks and gloves during food handling. Discard the masks and gloves when damaged, soiled or after prolonged use.
- Keep hands clean. Wash hands with running water and soap thoroughly for 20 seconds before handling food, after handling raw meat, poultry, raw seafood, dirty equipment, utensils and refuse.
- Do not handle food in case of sore throat or gastro-intestinal symptoms like diarrhoea and vomiting.
- Cover sore or cut on hands by coloured waterproof bandages.

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