ORIGINAL ARTICLE

THE PREVALENCE OF MICROBIOLOGICAL CONTAMINATION IN READY- TO- EAT FOOD AND FACTORS AFFECTING IT IN MELAKA

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ABSTRACT

Background: A cross sectional study was carried out to determine the prevalence of microbiological contamination in ready- to-eat food and factors affecting it in Melaka from February 2008 till May 2008 in collaboration with the Food Safety and Quality Unit and District Health Offices in Melaka Tengah, Alor Gajah and Jasin.

Methods: A purposive sampling of 101 food premises was carried out and 202 ready- to-eat food samples were collected and analysed microbiologically using standard methods. A total of 202 food handlers were randomly selected for questionnaire interview while rectal and nasal swabs were taken from them to determine their healthy carrier status of pathogenic food bacteria.

Results: Results showed that the overall prevalence of microbiological contamination in ready- to-eat food was 35.1%, while prevalence by type of food was 42.0% for main dishes and 9.8% for staple food. The majority of the contaminations were due to coliforms (14.9%), total plate counts (12.4%) and *Staphylococcus aureus* (3.5%). The mean score for food premise inspection was 77.21 ± 10.32 and the prevalence of healthy carrier status of pathogenic food bacteria among the food handlers was 15.8%**.** The level of food handling practices among food handlers was influenced by sex (p=0.012) and formal training on food handling courses (p=0.009). There was a significant negative correlation between age and level of food handling practices among the food handlers (r = -0.163; p = 0.02). Poor food handling practices (p=0.02) and poor hygiene status among the food handlers (p<0.01) were factors that influenced microbiological contamination of food samples. A logistic regression analysis showed that poor food handling practices (Odds ratio=3.50; 95% CI=1.35-9.06) and poor hygiene status among food handlers (Odds ratio=13.16; CI=3.65-47.44) were significantly associated with healthy carrier status of pathogenic food bacteria.

Conclusion: Poor food handling practices and poor hygiene status among food handlers were factors that influenced microbiological contamination of ready-to-eat food as well as healthy carrier status of pathogenic food bacteria.

Keywords: Ready- to- eat food, microbiological contamination, food handler, healthy carrier status, food handling practices, hygiene status.

Received Okt. 2010; Accepted Jun 2011
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INTRODUCTION

Food borne diseases caused by microbiological agents are still a major problem faced by developing countries such as Malaysia. The World Health Organization(WHO) estimated that 70% of diarrhea cases in the world are caused by infection of microbes[1]. Statistics from the Ministry of Health Malaysia showed that there is a three fold increase of food poisoning incidences reported within 10 years; from 8.44 per 100 000 populations in 1993 to 23.89 per 100 000 populations in 2004[2].

The concept of food hygiene and safety encompasses a wide scope inclusive of production, packaging, delivering, storing and preparing the food to be eaten. It also involves keeping and treating food, so it does not get contaminated by microbes that can lead to food borne diseases or food poisoning. Food contamination by microbes usually occurs due to unsafe food handling practices such as cross contamination from floor surfaces and raw food. It cannot be denied that contaminated food, dirty food premises, poor hygiene status and unsafe food handling practices among food handlers can cause food poisoning[3]. Food handlers can also become host to pathogenic food microorganisms such as *Salmonella sp.* and *Staphylococcus aureus* that are present in those showing symptoms of diarrheal diseases and respiratory tract infection even after they have recovered from the illness (convalescence period). With respect to food handling practices of food handlers, it can be divided into 2 categories namely practices directly related with food and practices indirectly related with food. These practices encourage bacterial contamination and multiplication and also support its endurance in contaminated food[4]. Practices directly related with food like not washing hands after working with meat, poultry or raw fish before handling ready- to-eat food will cause cross contamination.

Practices indirectly related with food refers to the hygiene status or cleanliness of the food handlers. This can be reflected through wearing clean clothes and aprons, having short and clean hair as well as fingernails and also wearing shoes while handling food in the premises. They also do not smoke or touch their nose or ear cavity while preparing food to be consumed. According to the Centre for Disease Control in the United States of America, between 1988 and 1992, the incidence of food poisoning in America caused by poor hygiene status of food handlers were 22%[5] .

Routine periodic inspections of food premises through the Food Quality and Safety Surveillance Programme of the Ministry of Health Malaysia are intended to prevent food and water borne diseases. This is done through a demerit marking system based on a checklist prepared by the Ministry of Health and agreed by all stakeholders which includes safe preparation of food, cleanliness of food handlers and surrounding sanitation of food premises (physical appearance, drainage, garbage disposal, toilet and clean water supply).

The aim of this study is to determine the prevalence of microbiological contamination in ready- to- eat foods as well as factors associated with food handlers which are related to microbiological contamination in foods such as personal hygiene status, food handling practices and healthy carrier status of pathogenic food bacteria. Sociodemographic factors of food handlers such as age, sex, ethnic group, level of education, length of service, formal training on safe food handling practices and food premises sanitation status are also studied to investigate their association with food handler's hygiene status, level of food handling practices and healthy carrier status of pathogenic food bacteria.

METHODOLOGY

A cross-sectional study was conducted in conjunction with the Food Surveillance Programme of Melaka Tengah, Alor Gajah and Jasin District Health Offices starting from February 2008 to May 2008. The sample population are licensed food premises in the the state of Melaka and the sampling frames are the list of licensed food premises in the 3 districts. The sample unit was a licensed food premise purposely chosen by an assistant environmental health officer in charge of Food Surveillance Programme. For each food premise, 2 food handlers and 1 or 2 ready- to-eat food samples for microbiological analysis were randomly selected based on a previous study done by Sazidah[6]. The required sample size was calculated based on formula "one sample situation" method from Lwanga and Lemeshow[7], using a prevalence rate of microbiological food contamination of 10% based on the Melaka State Health Department Report[8]. The calculated sample size was 138, based on 95% confidence interval and 80% statistical power. With a 10% non- response rate, the final sample size required for this study was 152 licensed food premises. Inclusion criteria for the food handlers were

those directly involved with the handling and preparation of food and could understand Bahasa Malaysia or could understand with the help of translators.

Data collection were done by using structured questionnaires to obtain data on food premises and sociodemographic profile of food handlers, using guided questionnaires to assess food handler's level of food handling practices, using a checklist to assess personal hygiene status, sampling of ready- to- eat food for microbiological analysis, obtaining nasal and rectal swabs from food handlers to screen for healthy carrier status of food pathogenic bacteria and food premise inspection using standard marking scheme by the Ministry of Health Malaysia. Premises with 50 % marks or more are considered as having satisfactory sanitation status while those with less than 50% marks are considered as having unsatisfactory sanitation status.

The data were analyzed using SPSS version 13.0 which involved descriptive and analytical analysis. Frequencies and percentages were calculated for categorical variables. Median and interquartile range were calculated for non-normal variables. Univariate analysis, bivariate analysis (correlation and chi square) and multivariate analysis (logistic regression) were used in this study. A p value of less than 0.05 is considered as being significant.

RESULTS

A total of 101 food premises were inspected, 202 ready- to- eat food were sampled and 202 food handlers were interviewed and their nasal and rectal swabs were taken and sent for microbiology analysis. The median duration that food premises has been in operation was 36 months and the median number of food handlers per premise was 4 persons. The mean score for food premises inspection was 77.21 ± 10.32. Results showed that total coliform was the major cause of contamination found in food samples (42.3%) followed by total plate count (35.2%), *Staphylococcus aureus* (9.9%), *Escherichia coli* (8.4%), *Salmonella species* (2.8%) and *Bacillus cereus* (1.4%) (Table 1). The prevalence of microbiological contamination in ready- to- eat foods was 35.1%, while prevalence by type of foods was highest among main dishes (42.0%) and staple food (9.8%).

Table 1 Microbiological contamination of food samples by type of bacteria.

Types of bacteria	**Number of food samples tested positive**	**Percentage (%)**
Total coliform	30	42.3
Total plate count	25	35.2
Stap.aureus	7	9.9
Escherichia coli	6	8.4
Salmonella spp	2	2.8
Bacillus cereus	1	1.4
Total	71	100.0

A total of 105 food handlers (52.0%) demonstrated good food handling practices by scoring 30 marks or more (≥ 75%) from 20 questions about food handling practices posed to them whereas 97 food handlers (48.0%) have poor food handling practices by scoring less than 30 marks (< 75%). The total score was 40 marks and the median score for all food handlers was 30 marks, with an interquartile range of 6.25 with a minimum score of 17 marks and a maximum score of 40 marks. The U Mann-Whitney Test showed that food handling practices scores were significantly higher among female food handlers and those who had undergone formal training course on safe food handling (Table 2).

Table 2 Food handling practices score and associated factors.

Variable	N	Food handling practice score		U Mann-Whitney Test	p value
Gender		25th	75th		
Male	98	29.00	2.06	6.19	
Female	104	30.00	1.25	3.75	Z = -2.513 **p =0.012***
Citizenship					
Non-Malaysian	21	33.00	1.50	4.50	Z = -1.880 p =0.060
Malaysian	181	29.00	1.75	5.25	
Age (years)					
< 30 years	75	31.00	1.75	5.25	
≥ 30 years	127	29.00	1.75	5.25	Z = -1.167 p =0.243
Level of education					
Up to primary school	54	29.00	1.56	4.69	
Secondary school & above	148	30.00	1.69	5.06	Z = -1.927 p =0.054
Food handling experience (years)					
< 6 years	133	30.00	1.75	5.25	
≥ 6 years	69	30.00	1.75	5.25	Z = -0.336 p =0.737
Formal training on food handling					
No	114	29.00	2.00	6.00	
Yes	88	31.00	4.87	1.63	Z = -2.623 **p =0.009***

*** Significant at p < 0.05**

It was found that among food handlers with poor food handling practices, the microbiological contamination rate detected in their food samples was 43.3% in comparison to 27.6% among food handlers with good food handling practices. The association is statistically significant as the p value is < 0.05 (χ^2 = 5.438, p = 0.02). For personal hygiene status, it was found that among food handlers with poor hygiene status, the microbiological contamination rate detected in their food samples was 49.6% in comparison to 16.9% among food handlers with good hygiene status. The association is also statistically significant as the p value is < 0.05 (χ^2 = 23.36, p < 0.001). Furthermore, it was found that among food handlers who were healthy carriers of pathogenic food bacteria, the microbiological contamination rate detected in their food samples was 46.9% in comparison to 32.9% among food handlers who were not healthy carriers. However, the association is not statistically significant as the p value is > 0.05 (χ^2 = 2.294, p = 0.130) (Table 3).

Out of the total 101 food premises being inspected, 37 food premises had microbiological contamination detected in their food samples. Out of these 37 food premises, 36 food premises had satisfactory sanitation status and 1 food premise had unsatisfactory sanitation status. However, statistical analysis did not show a significant association between food premise sanitation status and microbiological contamination in food samples (p = 0.366) (Table 3).

Table 3 Association between food handling practices, personal hygiene status, healthy carrier status of pathogenic food bacteria and food premise sanitation status among food handlers and microbiological contamination in food samples.

Factors	**Microbiological contamination**			**Chi- square**	
	Yes(%)	**No(%)**	**Total(%)**	**χ^2 value**	**p value**
Food handling practices level					
Poor	42(43.3)	55(56.7)	97(100.0)	5.438	**p =0.020***
Good	29(27.6)	76(72.4)	105(100.0)		
Total	71(35.1)	131(64.9)	202(10.0)		
Personal hygiene status					
Poor	56(49.6)	57(50.4)	113(100.0)	23.36	**p <0.001***
Good	15(16.9)	74(83.1)	89(100.0)		
Total	71(35.1)	131(64.9)	202(100.0)		
Healthy carrier status of pathogenic food bacteria					
Present	15(46.9)	17(53.1)	32(100.0)	2.294	p =0.130
Absent	56(32.9)	114(67.1)	170(100.0)		
Total	71(35.1)	131(64.9)	202(100.0)		
Food premise sanitation status					
Unsatisfactory	1(100.0)	0(0)	1(100.0)	1.747	p = 0.366

Satisfactory	36(36.0)	64(64.0)	100(100.0)
Total	37(36.6)	64(63.4)	101(100.0)

*** Significant at p < 0.05**

Among those with poor food handling practices, it was found that 10 of them (10.3%) were healthy carriers of pathogenic food bacteria in comparison to 22 (21.0%) among those with good food handling practices. Even though the association is statistically significant ($\chi^2 = 4.28$, p= 0.038), the result is unexpected as it shows that good food handling practices are associated with a healthy carrier status (Table 4).

Furthermore, out of the 202 food handlers inspected, 113 (55.9%) had poor personal hygiene status and 89 (44.1%) food handlers had good personal hygiene status. Out of the 113 food handlers with poor personal hygiene, 29 (25.7%) were detected to have healthy carrier status of pathogenic food bacteria in comparison to only 3 (3.4%) among those with good personal hygiene status. The association between personal hygiene status and presence of healthy carrier status of pathogenic food bacteria was found to be statistically significant (χ^2= 18.56, p< 0.001) (Table 4).

Table 4 Association between food handling practices and personal hygiene status among food handlers with their healthy carrier status of pathogenic food bacteria

Factors	**Healthy carrier status**			**Chi- square**	
	Yes(%)	**No(%)**	**Total(%)**	**χ^2 value**	**p value**
Food handling practices level					
Poor	10(10.3)	87(89.7)	97(100.0)	4.28	**p =0.038***
Good	22(21.0)	83(79.0)	105(100.0)		
Total	32(15.8)	170(84.2)	202(100.0)		
Personal hygiene status					
Poor	29(25.7)	84(74.3)	113(100.0)	18.56	**p <0.001***
Good	3(3.4)	86(96.6)	89(100.0)		
Total	32(15.8)	170(84.2)	202(100.0)		

*** Significant at p < 0.05**

Multivariate logistic regression analysis revealed that variables which significantly influenced (p<0.05) the healthy carrier status of pathogenic food bacteria among the food handlers were their poor food handling practices (OR = 3.502 CI 95% = 1.354 -9.060) and poor personal hygiene status after controlling for selected socio-demographic variables (OR = 13.159, CI 95% = 3.650 - 47.437) (Table 5).

Table 5 Logistic regression analysis showing the influence of poor food handling practices and poor personal hygiene status on the healthy carrier status of pathogenic food bacteria among food handlers, after controlling for selected socio-demographic variables.

Variables	Code	ß Coefficient	Odds Ratio (OR with 95% CI)	p value
Age	0: <30 yr; 1: ≥30y	-0.657	0.519(0.216-1.243)	0.141
Gender	0:male; 1:female	0.299	1.348(0.557-3.264)	0.508
Citizenship	0:non citizen; 1:citizen	- 0.209	0.811(0.208-3.159)	0.763
Education	0:nil/up to primary school 1:secondary school & onwards	-0.689	0.502(0.194-1.300)	0.156
Working experience	0:<5yr; 1:≥5yr	-0.898	0.407(0.152-1.096)	0.075
Formal training	0:untrained; 1:trained	0.112	1.118(0.440-2.844)	0.814
Food handling practices level	0: Low ; 1:High	1.253	3.502(1.354-9.060)	**0.010**
Personal hygiene status	0:Bad; 1:Good	2.577	13.159(3.650-47.437)	**0.001**
Constant		-5.147	0.006	0.014

*** Significant at p < 0.05 Coding: carrier = 1 non-carrier = 0**

DISCUSSION

This study found that a total of 71 (35.1%) food samples collected were microbiologically contaminated. This is more than that discovered by Sazidah[6] at 30.3% and that by the Food Quality Control Section of the Ministry of Health, Malaysia[9] at 24.3%. Total coliform was the major cause of microbiological contamination found followed by total plate count, *Staphylococcus aureus*, *Escherichia coli, Salmonella sp.* and *Bacillus cereus.* This finding is similar with that Sazidah[6] who also found that total coliform was the major cause of microbiological contamination found in food samples followed by *Escherichia coli,* total plate count, *Bacillus cereus, Staphylococcus aureus* and *Salmonella sp.* Research conducted by the Food Quality Control Section of the Ministry of Health, Malaysia[9] found that total coliform was the major microbiological contamination found followed by total plate count. Result also showed that main dishes were the most contaminated food samples (42.0%) followed by staple foods (9.8%). This is different from

Sazidah[6] who found that staple foods were the most contaminated food samples (51.1%) followed by "kuih" (31.0%) and main dishes (21.0%). This difference probably existed because the food sampling done in this study has to comply with the Microbiological Standards in the Food Act and Regulations[10] which stated that food samples taken for microbiological analysis should be a ready- to-eat food that are meat or fish based.

In this study, it was found that out of 101 food premises, the prevalence of microbiologically contaminated food premises (according to the pre determined definition of having one or more ready- to- eat food sample that is contaminated) in the 3 districts in Melaka was 35.6%. This was lower than Sazidah's[6] study in 3 districts in Selangor covering 94 food premises where the prevalence was 50% using the same pre determined definition.

It was found that level of food handling practices was significantly higher amongst female food handlers and those that had undergone formal training on food handling courses. Factors such as citizenship, age, level of education and working experience in food handling did not have a significant relationship with the level of food handling practices. This findings concur with that of Manning[11] and Buccheri[12] which also found female food handlers to have significantly higher level of food handling practices compared to male food handlers. Contrary to the results of this study, Buccheri[12] and Zain & Naing[13] found that there was no significant difference in the level of food handling practices between food handlers who have and have not undergone formal training on food handling courses. This difference in the study results may be due to the difference in time and the locations where the studies were being done.

This study found that among the 202 food handlers being studied, a majority (55.9%) of them had poor personal hygiene status even though most (99.0%) of the food premises being inspected had satisfactory sanitation status (premise sanitation score ≥50 marks). This shows that good premise sanitation score does not reflect good personal hygiene status of the food handlers working in these premises. Bryan[4] stressed that good personal hygiene status and good food handling practices were the basis of preventing food pathogens from food handlers to food consumers. Results also showed that 32 (15.8%) food handlers were healthy carrier of *Staphylococcus aureus* detected through their nasal swabs while none were carrier for *Salmonella sp.* through their rectal swabs. A study done by Atif[14] on 259 food handlers in Mecca has found that 54 (20.8%) of them were healthy carriers of *Staphylococcus aureus* detected through their nasal swabs while only 2 (0.8%) were detected carrier for *Salmonella sp.* through their rectal swabs. Meftahudin[15] who studied 180 food handlers in Ipoh found 6.6% of them were healthy carriers of *Staphylococcus aureus* and 1.6% of them were healthy carriers of *Salmonella sp.* The difference in the prevalence rate of healthy carriers of pathogenic food bacteria that existed between different study areas and time is probably reflective of the variability in the level of practice and hygiene status among food handlers as well as the environment where the studies were done. Mohan[16] stressed the importance of scheduled examination of food handlers to ascertain their healthy carrier status of pathogenic food bacteria. Fielding[17] also agreed on the need of a screening programme to determine the healthy carrier status of pathogenic food bacteria among food handlers before the issuance of certificate of fitness to them to work in food industries.

Result from this study has clearly indicated that microbiological contamination of food samples was significantly associated with poor food handling practices and personal hygiene status of food handlers. Poor food handling practices was in turn associated with male food handlers and those who have not undergone formal training on safe food handling. This is contrary to the study by Sazidah[6] who found no significant relationship between microbiological contamination of food samples and food handling practices among food handlers. On the other hand, this study found that microbiological contamination of food samples was not significantly associated with food handler's healthy carrier status of pathogenic food bacteria and food premise sanitation level. This is contrary to Zaliha[18] who found that food premises with demerit score less than 50 (reflecting low sanitation level) had significantly higher rate of microbiological contamination of food samples compared to premises with score more than 50. Following multivariate analysis using logistic regression, it was found that food handlers with poor food handling practices and poor personal hygiene status have significantly higher risk of becoming healthy carriers of pathogenic food bacteria, and this finding is consistent with that of Mohan[16]. There are some limitations of this

study which need to be considered. As it is a cross- sectional study, it cannot show a cause and effect relationship. For cost effective reason, the study was conducted in collaboration with Food Surveillance Programme Melaka State Health Department and has to follow food sampling scheduled (microbiology) and food specimen limitation per day which have already being fixed by Chemical Department Laboratory for the whole year, causing less food premises can be sampled during study period. Some food handlers did not give full cooperation during the interview session and during the process of taking nasal and rectal swabs which led to a non- response bias. On top of that, information bias could not be avoided as the interview response depended on the sincere answers from the respondents.

CONCLUSION

The prevalence of microbiological contamination in ready- to- eat food from this study was 35.1% and the prevalence of microbiologically contaminated food premises was 35.6%. These rates were high, even though the rate of food premises that achieved good sanitation level (demerit score equals or more than 50) was high at 99.0%. This results reflected that good sanitation level of food premises did not ensure that food being prepared was free from microbiological contamination. Continuous interventions by Public Health Authority through health education, enforcement and periodic surveillances of food quality and food handlers' personal hygiene status and practices are of the utmost importance in order to protect consumers from food poisoning and food borne illnesses. The prevalence of healthy carriers of pathogenic food bacteria among food handlers in this study was 15.8% and this healthy carrier status was influenced by poor food handling practices and personal hygiene status of the food handlers.

ACKNOWLEDGEMENT

This study was supported by Hospital Universiti Kebangsaan Malaysia research grant. (Ref: FF-131-2007). The authors would like to thank the late Professor Dr. Md. Idris Mohd. Nor and Dr. Noorlaili Abdul Aziz, State Health Director of Melaka as well as all the food handlers who participated in the study.

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