BORNEO SCIENCE 11: 9-22, JUNE 2002

MICROBIOLOGICAL SAFETY OF READY-TO-EAT FOODS FROM RESTAURANTS AND HAWKER CENTRES IN KOTA KINABALU, SABAH.

Chye Fook Yee & Lim Chui Ngoh

School of Food Science & Nutrition,
Universiti Malaysia Sabah, 88999 Kota Kinabalu, Malaysia

ABSTRACT. *A total of 117 samples of ready-to-eat foods from hawker centres and restaurants in Kota Kinabalu were examined to determine the aerobic plate count (APC), coliform, Escherichia coli and Staphylococcus aureus as well as selected pathogens such as Listeria monocytogenes, Salmonella spp and Escherichia coli 0157:H7. Approximately 56% samples had APC levels above the maximum limit (>10^6 cfu/g) permitted by the Food Act 1983 and Food Regulation 1985. The detection rate for coliforms was highest in meat whereas egg samples were the lowest. E. coli was detected in all groups of food samples with the highest count for vegetable samples. The highest mean for S. aureus was found in egg samples (4.6 x 10^4 cfu/g), followed by meats (3.4 x 10^4 cfu/g), vegetables (2.3 x 10^4 cfu/g), chickens (2.0 x 10^4 cfu/g) and fishes (1.3 x 10^3 cfu/g). Samples taken from premises which hygiene training had been given to their food handlers had a better microbiological quality as compared with those without training. E. coli 0157:H7 was only detected in 6% of the samples and was not detected in fish. However, all food samples were negative for Salmonella and L. monocytogenes. Based on these results, it was concluded that the microbiological quality of foods sold in Kota Kinabalu was unsatisfactory and the prevalence of certain pathogens such as E. coli and E. coli 0157:H7 significantly indicating a potential risk to consumers.*

KEYWORD. Foodborne pathogens, food safety, Sabah

INTRODUCTION

The ready-to-eat (RTE) food product provides a source of readily available and nutritious meals for the consumer. As the demand for RTE foods increase, a great variety of these foods are becoming available and more people are eating away from their home especially during lunch hour because they do not have time for cooking. Food is the major source of exposure to pathogenic agents, both chemicals and biological (bacteria, viruses and parasites). Foods contaminated with unacceptable levels of pathogens and chemical or having other hazardous characteristics, imposed substantial health risks to consumer, as well as to health care cost. These cost included the expenses entailed in controlling the

disease, medical treatment cost, business losses, and losses in productivity (IFST, 1995). Furthermore, many developing countries do not have a comprehensive food safety programme, while most food-borne disease are sporadic and often not reported (WHO, 2000). Food poisoning in Malaysia was increasing every year. For instance in 1995, the number of cases was 1,438 compared to 8,640 cases in 1999 and most of cases happened in school. Whereas in Sabah, number of food poisoning cases has rise to 863 cases in 1999 from 37 cases in 1995 (MOH, 2002). Among the etiology agents were *Staphylococcus aureus*, *Esherichia coli* and *Salmonella* spp.

Since outbreaks of illness in human beings are understood to be caused by consumption of contaminated foods, several reports have been published that described the bacteria contamination of RTE foods (Kaneko *et al.*, 1999; Mosupye and Von Holy, 2000). Chiou et al (1996) examined the microbial quality of 300 RTE food products sold in Taiwan, which were kept hot. Their results indicated that the percentage of foods not meeting the microbiological standard accepted by the authority regarding to aerobic count, coliform and *E. coli* were 17.7%, 20.3% and 8.0% respectively. According to Centers for Disease Control and Prevention, USA 77% of foodborne illnesses are attributed to foodservice operations, 20% to homes, and 3% to food processing plants (Dykstra and Schwarz, 1991). The scale and ubiquitous nature of contamination of raw materials of animal as well as vegetable origin with enteric pathogens is compounded, in a great many countries, by an unreliable water supply, a lack of consistent refrigeration, and a poor knowledge of even an elementary level of applied food microbiology (Ehiri *et al.*, 1997).

In Sabah and other states of Malaysia where street-food vending is common, there has been little information regarding the incidence of street-food related diseases. Therefore, the purpose of this study was to establish the microbiological quality and food safety of ready-to-eat foods sold in Kota Kinabalu areas on relation to levels of aerobic plate counts, coliform counts, *E. coli* and some selected pathogens. In addition, the study also sought to determine microbiological quality associated with premises type and relationship between hygiene training course and microbiology quality.

MATERIALS AND METHODS

Sampling Procedure

High risk cooked food samples such as beef, chicken, fish, egg and vegetables were selected and purchased between 11.00 am to 1.00 pm from hawker centers/restaurants in Kota Kinabalu areas (Town, Inanam and Menggatal). The samples, which packaged

individually with sterile whirl-pak bags, were kept in cool-box (below 5°C) and delivered to the laboratory within 2 hours. Analyses of the samples were conducted either immediately after arrival in the laboratory, or following overnight storage within 24 hours in the refrigerator.

Microbiological Analyses

The pour-plate technique was used to determine aerobic plate count (APC). Samples (25 g) were weighed into sterile stomacher bags, mixed with 225 ml saline-water (0.85%) and homogenized in Bag Mixer™ stomacher for 30 seconds (10^{-1} dilution), followed by serial dilutions. Plates were incubated at 37°C for 48 hours. Samples were also analysed for coliforms and *E. coli* by using most probable number technique (MPN). Differentiation of *E. coli* and nonfecal coliforms isolated from the samples was carried out by IMViC tests (Marshall, 1993). For enumeration of *S. aureus*, serial dilutions food samples were plated onto Baird-Parker agar (BPA, Merck Germany) with egg yolk emulsion (50 ml L^{-1}), and incubated at 37°C for 24 – 48 hours. Typical colonies were subjected to coagulase using Bactident Coagulase (Merck, Germany) and *S. aureus* ATCC 25923 used as positive control.

For the detection of *Salmonella* spp., 25 g of food samples was mixed with 225 ml buffered peptone water 0.1% (Merck, Germany), homogenized for 30 seconds, and incubated at 37°C for 24 hours. The pre-enrichment broth culture (1.0 ml) was added to 10 ml Selenite Cystine broth (SCB, Merck Germany) and 10 ml Tetrathionate broth (Merck, Germany), which were incubated for 24 hours at 37°C and 44°C, respectively. A loopful of each enrichment broth culture was streaked onto Bismuth Sulphite agar (BSA, Merck Germany) and Brilliant Green agar (BGA, BBL USA). The plates were then incubated at 37°C for 24 hours. Pure culture *S. typhimurium* 865 was used as positive control. Typical colonies from BSA and BGA were streaked onto Triple Sugar Iron agar (TSI, Merck Germany) and Motility Indole Ornithine agar (MIO, Difco USA) for presumptive test. Confirmation was carried by using the API system 20E Identification Kit (bioMerieux, France).

In order to test for *L. monocytogenes*, 25 g of food sample was mixed with 225 ml of *Listeria* enrichment broth (Merck, Germany) and homogenized for 30 seconds. The enrichment broth culture was incubated at 37°C for 24 hours. A loopful of the culture was streaked after 24 hours onto Oxford-Listeria-Selective agar (Merck, Germany), and Palcam-*Listeria*-Selective agar (Merck, Germany), which were then incubated at 37°C for 24 hours (Wang *et al.*, 1992). For positive control, *L. monocytogenes* L55 was used. Presumptive colonies were identified based on catalase activity, umbrella motility and biochemical test with TSI. Confirmations were carried out using the API *Listeria* System Identification Kit (bioMerieux, France).

The presence of *E. coli* O157:H7 was determined using Sorbitol MacConkey agar (SMC, Merck Germany) as described by Mosupye & Von Holy (1999). Approximately 4 – 5 typical colonies were streaked onto Ethylene Methylene Blue agar (EMB, Merck Germany), which were then incubated at 37^{0}C for 24 hours. Presumptive positives colonies were confirmed by IMViC test and followed by using *E. coli* O157:H7 Rapid Latex Test Kit (Oxoid, England).

Statistical Analysis

Data were evaluated using the SPSS programme (Verse 10.01) including one-way ANOVA, correlation coefficients and t-tests.

RESULTS AND DISCUSSION

Mean bacterial counts of RTE food samples are shown in Table 1. Food from meat and vegetables groups were found to have a significant higher ($p<0.05$) bacterial counts as compared to other food samples with mean APC of 1.6×10^7 cfu/g and 1.7×10^7 cfu/g, respectively. Raw meat, poultry and vegetables are commonly contaminated with large numbers of bacteria including potential foodborne pathogens and these bacteria could also present in the corresponding cooked foods if cooking process was not properly done. Improper management during distribution and display in retail shops allow the bacteria to grow quickly (Kaneko *et al.*, 1999). Most of the ready-to-eat foods/cooked foods were kept in the tray/ containers and kept at room temperature before serving. These could be the reason that almost 40% of the food poisoning cases happened in Malaysia was due to improper storage or holding temperature.

Generally, 28% of the food samples collected were found to have mean APC values above 10^7 cfu/g (Table 2) and approximately 56% samples had APC levels above the maximum limit (>10^6 cfu/g) permitted by Food Act 1983 and Food Regulations 1985. Vegetable samples had the highest rate (90%) of non-compliance with standards, followed by meat (65%) and egg (44%) samples. Although high APC value does not constitute a risk to health, but it may sometimes indicate a general lack of hygiene, the cooling process was inadequate, post-cooking contamination had occurred, the temperature of post-cooking storage was inadequate to prevent bacterial growth or a combination of these factors were involved (IFST, 1997). Albrecht *et al.* (1995) has pointed out that bacterial contamination in foods is common especially in most of the studies recently. Foods contain high-protein makes it a highly favourable medium for microorganisms. However, result of this study showed that most of the fish samples have lower bacteria counts compared to meat, chicken and egg samples. This may associated with cuisine type and usage of herbs or

spices in cooking. Some spices and vegetables such as onions/garlic and chilly were found to contain broad-spectrum antimicrobial substances that exhibit both antibacterial and antifungal properties (Cutter, 1999).

Table 1: Bacteriological quality of different categories of RTE foods.

Type of food	Mean Bacteria Counts			
	APC (cfu/g)	Coliform (MPN/g)	*E. coli* (MPN/g)	*S. aureus* (cfu/g)
Meat(n = 20)	1.6×10^7	7.0×10^2	1.1×10	3.4×10^4
Chicken(n = 30)	6.8×10^6	4.7×10^2	2.0×10	2.0×10^3
Fish(n = 22)	1.3×10^6	3.9×10^2	1.2×10	1.3×10^3
Egg(n = 25)	1.4×10^6	3.7×10^2	3.8×10	4.6×10^4
Vegetable(n = 20)	1.7×10^7	6.7×10^2	1.1×10^2	2.3×10^4

n - number of samples

Table 2: Microbial profile and distribution of RTE foods.

Test	Type Of Food	ND	< 50	50 - < 10^2	10^2 - <10^3	10^3 - <10^4	10^4 - <10^5	10^5 - <10^6	10^6 - <10^7	> 10^7
APC	Meat	-	-	-	-	1 (5.0)	-	1(5.0)	5(25.0)	13(65.0)
(cfu/g)	Chicken	-	-	-	-	3(10.0)	9(30.0)	7(23.3)	6(20.0)	5(16.7)
	Fish	-	-	-	1 (4.5)	3(13.6)	5(22.7)	6(27.3)	7(31.8)	-
	Egg	-	-	-	-	-	7(28.0)	7(28.0)	11(44.0)	-
	Vegetable	-	-	-	-	-	-	2(10.0)	3(15.0)	15(75.0)
Sub-total		0	0	0	1 (0.8)	7 (6.0)	21 (17.9)	23 (19.6)	32 (27.4)	33 (28.2)
Coliform	Meat	-	4(20.0)	4(20.0)	-	12(60.0)	-	-	-	-
(MPN/g)	Chicken	2(6.7)	5(16.7)	-	15(50.0)	8(26.7)	-	-	-	-
	Fish	1(4.5)	8(36.4)	1(4.5)	7(31.6)	5(22.7)	-	-	-	-
	Egg	-	8(32.0)	-	13(52.0)	4(16.0)	-	-	-	-
	Vegetable	-	5(25.0)	3(15.0)	-	12(60.0)	-	-	-	-
Sub-total		3 (2.6)	30 (25.6)	8 (6.8)	35 (29.9)	41 (35.0)	0	0	0	0
E. coli	Meat	11(55.0)	9(40.0)		-	-	-	-	-	-
(MPN/g)	Chicken	28(93.3)	-		2(6.7)	-	-	-	-	-
	Fish	20(90.9)	1(4.5)		1(4.5)	-	-	-	-	-
	Egg	22(88.0)	-		3(12.0)	-	-	-	-	-
	Vegetable	11(55.0)	7(35.0)		2(10.0)	-	-	-	-	-
Sub-total		92 (78.6)	17 (14.5)		8 (6.80	0	0	0	0	0
S. aureus	Meat	5(25.0)	2(10.0)		6(30.0)	-	2(10.0)	5(25.0)	-	-
(cfu/g)	Chicken	21(70.0)	3(10.0)		4(13.3)	-	2(6.7)	-	-	-
	Fish	18(81.8)	-		2(9.1)	1(4.5)	1(4.5)	-	-	-
	Egg	20(80.0)	2(8.0)		-	1(4.0)	-	2(8.0)	-	-
	Vegetable	6(30.0)	-		4(20.0)	3(15.0)	4(20.0)	3(15.0)	-	-
Sub-total		70 (59.8)	7 (6.0)		16 (13.6)	5 (4.3)	9 (7.7)	10 (8.5)	0	0

ND - not detected in 25 g of samples Detectable limit for *E. coli* and *S. aureus* is < 10^2 ( ) - percentage

The highest mean for coliform counts was found in meat samples (7.0×10^2 MPN/g), followed by vegetables and chicken samples (6.7×10^2 MPN/g and 4.7×10^2 MPN/g) (Table 1). Meanwhile fish and egg samples had the lowest counts with the value of 3.9×10^2 and 3.7×10^2, respectively. Coliform was not found in 2.6% of samples and 25.6% ranged less than 50 MPN/g. The largest population distribution for coliforms was found in the range of 10^3 to $<10^4$ MPN/g (Table 2). However, almost 72% of the food samples were not compliant with microbiological standard (50 MPN/g) accepted by the government. Of the result, 60.0% of meat and vegetable samples ranged from $10^3 - 10^4$ MPN/g compared to chicken (26.7%), fish (22.7%) and egg (16.0%). The reason may be due to contaminated raw material, cross contamination during preparation or high storage temperature. Coliforms on these products reflect the initiate microflora of the vegetables in growing fields and the recontamination during cutting and further processing. Majority of chicken (50.0%) and egg (52.0%) samples ranged from $10^2 - 10^3$ MPN/g. Meanwhile almost 36% of fish samples ranged less than 50 MPN/g. The presence of coliform ready-to-eat foods shown that there were cross-contamination occurred either direct or indirect. Among the factors were poor personal hygiene, inadequate cleaning methods, and lack of facilities for the segregation of raw and cooked foods (Jay *et al.*, 1999).

E. coli was found in 21% of the food samples analysed and the highest mean was found in vegetable samples (1.1×10^2 MPN/g) (Table 1). Chicken samples have the lowest occurrence of *E. coli* since the organism was not detected in 93.3% of the samples compared to fish (90.9%) and egg (88.0%) samples. On the other hand, *E. coli* was detected in 40.0% of meat and 45.0% of vegetable samples (Table 2). According to the regulation, *E. coli* should not be present in all cooked foods. Study shown that the unhygienic practices included improper hand-washing techniques and lack of hand washing with soap for 20 seconds is efficient to remove/reduce microorganisms than using sanitized such as 70.0% alcohol (Charbonneau *et al.*, 2000). A significant correlation ($p<0.05$) was found between *E. coli* with coliform and *E. coli* with APC. Samples with higher numbers of coliforms and aerobic bacteria usually will also have higher counts of *E, coli*. However, the relation of coliforms and *E. coli* were not observed ($p>0.05$) in meat, vegetable and egg samples. Besides genus *Escherichia*, other genus like *Klebsiella*, *Citrobacter* and Enterobacter were present in coliform groups (Hui et al., 1994). Soriano et al. (2000) reported that some coliform such as *Klebsiella pneumoniae*, *Klebsiella oxytoca*, *Citrobacter freundii*, *Enterobacter cloacae* and *Serratia* spp. were isolated in Spanish potato omelette samples.

Mean *S. aureus* values for egg samples were the highest (4.6×10^4 cfu/g), compared with those for meat (3.4×10^4 cfu/g), vegetable (2.3×10^4 cfu/g), chicken (2.0×10^3 cfu/g) and fish (1.3×10^3 cfu/g) (Table 1). Although there is no regulation specifically for *S. aureus* in RTE foods, the presence of this bacterium in food samples indicates improper handling and possible cross-contamination (Snyder, 1998) and more importantly could be associated with present of enterotoxin in food. *S. aureus* is the most commonly found foodborne

pathogens in Malaysia. Based on the APHA Guidelines on *S. aureus* (Diane, 1995), 34.2% of the food samples were categorised as unsatisfactory microbiological quality, and 16.2% were of unacceptable microbiological quality. Furthermore, 25% of meat samples have means *S. aureus* counts ranged from 10^5 – 10^6 cfu/g, followed by vegetable (15.0%), and egg (6.0%), respectively. Human skin and nasal membranes are the main reservoir of staphylococci (Jablonski and Bohach, 1997), which may contribute to the contamination of products during distribution and handling if the conditions allow for bacterial growth and toxic production.

The microbiological quality of foods sold in premises with trained food handlers and without trained food handlers were compared. Mean APC for meat, chicken and egg samples from premises which hygiene training haven't given to the food handlers were 1.9 x 10^7 cfu/g, 1.0 x 10^7 cfu/g and 1.4 x 10^6 cfu/g, much higher than those with training (Table 3). Moreover, there were significant differences ($p<0.05$) in all count types between food samples collected from the two groups of food premises. Therefore, this study has shown that the importance and effectiveness of hygiene training course. In the other hand, there was no different in term of microbiological quality for food from hawker centers and restaurants. The highest mean APC was found in meat samples from hawker centers (2.3 x 10^7cfu/g) compared to the same samples from restaurants (1.4 x 10^7 cfu/g).

Egg samples from premises which hygiene training had been given to their food handlers have the lowest counts of coliform (2.7 x 10^2 MPN/g), followed by vegetable (3.3 x 10^2 MPN/g, chicken (3.4 x 10^2 MPN/g), meat and fish (5.9 x 10^2 MPN/g) (Table 3). On the other hand, the lowest mean of coliform counts was found in fish samples (3.2 x 10^2 MPN/g) prepared by food handlers who haven't undergone food hygiene training. Hygiene training course are important and necessary in order to increase the safety knowledge of the food handlers. Therefore, the local Public Health Authority has implemented policy that food handlers should attend hygiene training since 1996 before they can work in food services sectors (KKCH, 2000). Coliform counts for vegetable samples from hawker centers (8.4 x 10^2 MPN/g) were much higher than from restaurants (6.3 x 10^2 MPN/g) whereas counts for meat, chicken, fish and egg samples from hawker centers were lower compared to restaurants. However, no significant ($p>0.05$) differences were found among the samples from different type of premises. Hands are one of the principal vehicles for the cross-contamination of infectious agents onto ready-to-eat foods. Effective hand washing is therefore of great important in terms of successful hygienic food preparation, as it prevents this route of transmission and thereby helps to prevent the spread of infectious disease (Snelling *et al.*, 1991; Restaino & Wind, 1990).

Results of this study shown that contamination of *E. coli* and *S. aureus* were lower in samples taken from premises which food hygiene training have been given to their food handlers as compared with those without training. Food handler plays an important role in

the prevention of foodborne diseases. An infected food handler has been identified as possible source of outbreak in many countries (Sewell and Farber, 2001). They must ensure that there is no opportunity for potentially contaminated items comes into contact with foods that there are to be eaten without further heat treatment. Although meat samples from hawker centers seem to have a higher *S. aureus* count, however, no significant differences ($p>0.05$) were observed between the premises. *S. aureus* was the most frequently detected pathogenic organism (40.2%) indicative of the poor hygiene practices of the vendors regardless of the type of food sold. Food microbiological quality from both premises can be improved through effectiveness sanitation programme.

Table 3: Bacterial quality of RTE in premises with different status of hygiene training.

Type of food	Mean APC (cfu/g)		Mean Coliform (MPN/g)		Mean *E. coli* (MPN/g)		Mean *S. aureus* (cfu/g)	
	With training	Without training	With training	Without training	With training	Without training	With training	Without training
Meat	1.4×10^{6} (n = 7)	1.9×10^{7} (n = 13)	5.9×10^{2} (n = 7)	5.2×10^{2} (n = 13)	1.6×10 (n = 7)	9.0×10^{0} (n = 13)	3.4×10^{4} (n = 7)	3.2×10^{4} (n = 13)
Chicken	1.1×10^{6} (n = 11)	1.0×10^{7} (n = 19)	3.4×10^{2} (n = 11)	5.5×10^{2} (n = 19)	1.4×10 (n = 11)	2.4×10 (n = 19)	4.0×10^{3} (n = 11)	8.9×10^{2} (n = 19)
Fish	1.4×10^{6} (n = 6)	1.2×10^{6} (n = 16)	5.9×10^{2} (n = 6)	3.2×10^{2} (n = 16)	3.5×10 (n = 6)	3.0×10^{0} (n = 16)	1.7×10 (n = 6)	1.8×10^{3} (n = 16)
Egg	1.0×10^{6} (n = 9)	1.4×10^{6} (n = 16)	2.7×10^{2} (n = 9)	4.2×10^{2} (n = 16)	5.1×10 (n = 9)	3.1×10 (n = 16)	2.0×10^{0} (n = 9)	7.2×10^{4} (n = 16)
Vegetable	7.0×10^{7} (n = 7)	2.2×10^{7} (n = 13)	3.3×10^{2} (n = 7)	8.6×10^{2} (n = 13)	6.0×10^{0} (n = 7)	1.7×10^{2} (n = 13)	2.3×10^{4} (n = 7)	2.4×10^{4} (n = 13)
Total	5.0×10^{6} (n = 40)	1.1×10^{7} (n = 77)	5.0×10^{2} (n= 40)	5.3×10^{2} (n = 77)	5.0×10^{0} (n = 40)	5.0×10^{0} (n = 77)	5.0×10^{0} (n = 40)	5.0×10^{2} (n = 77)

n = number of sample

One of the greatest controls is the implementation of food premises grading system based on their hygiene practices and provides sufficient information for consumer to decide where to eat. However, the success of this programme in reducing risk factors associated with food safety is still unknown. Meanwhile, the requirement of health certificate when applying license to operate food premise could also be another control measures taken by local authority to ensure food safety (KKCH, 2000).

The prevalence of pathogenic bacteria in cooked foods sold in Kota Kinabalu areas are shown in Table 4. *E. coli* O157:H7 was detected in all food samples except fish. The highest percentages of positive *E. coli* 0157:H7 were found in meat (10.0%), followed by egg (8.0%), chicken (6.7%) and vegetable (5.0%), respectively. Significant correlation ($p<0.05$) was showed between the presence of *E. coli* and *E. coli* O157:H7 in foods. Many of the reported outbreaks have been associated with fresh produce and probably contaminated before it reached the kitchen (Cody *et al.*, 1999). The presence of *E. coli* O157:H7 in cooked food showed an inadequate heat treatment since *E. coli* O157:H7 can be easily killed at 68.3°C for 15 seconds (Jackson *et al.*, 1996). Therefore, to remain safe, the foods must be held either for only a short period or at temperatures above that at which pathogens cannot multiply. The exact origin of the *E. coli* 0157 contamination could not be determined, however it may have been resulted from poor handling practices and improper storage conditions. Cross-contamination appeared to be greater in the kitchens of café, restaurants and hotels than in those of school, hospital and staff canteen because formal training had been given to those food handlers from school and hospital compared to other food premises.

Test for *L. monocytogenes* was negative in 117 food samples. However only a strain of *L. ivanovii* was isolated in vegetable samples (5.0%) Absence of *L. monocytogenes* in these foods may be explained by antibacterial effects of some spices (Arora and Kaur, 1999), which are commonly used in cooking. Furthermore, the background flora present on the produce might also have an inhibitory effect on *L. monocytogenes*. Gohil et al. (1995) have also reported negative tests for *L. monocytogenes* but four positive tests for *L. innocua* in 183 samples of fresh retail vegetables. In contrast, Arumugawamy *et al.* (1994) reported that *L. monocytogenes* was found in 22 of 76 ready-to-eat foods sold in Malaysia and the percentage of detection was higher in cucumber (slices) served with the satay. However, the detection rate of *L. monocytogenes* in cooked foods was low compared to raw foods (Uyttendaele *et al.*, 1999; Arumugassawamy *et al.*, 1994).

Salmonella spp. were not detected in any of the samples analysed. The absence of *Salmonella* spp may reflect the very low occurrence of this pathogen in cooked foods. Consequently, these results also indicated that the thermal processing and the holding temperatures of the RTE foods were effective in maintaining the microbiological safety of the foods. The isolation of *Salmonella* in food samples is difficult because they may be present in relatively low numbers, often in the presence of high numbers of closely related

competitor organisms (Baylis *et al.*, 2000). The recovery and growth of the *Salmonella* spp. may be adversely affected by inhibitory metabolites produced by other bacteria, the depletion of available nutrients (Litchfield, 1973) and high concentrations of other Gram-negative bacteria may also cause the *Salmonella* to enter a premature stationary phase of growth before detectable numbers have been attained (Jameson, 1962). Heinitz *et al.* (2000) shown that the detection rate for *Salmonella* in cooked foods or ready-to-eat foods was relatively low (2.0%) as compared to raw foods. In addition, higher isolation rate of *Salmonella* was found in food origin from animal such as meat and chicken. Nevertheless, to determine the presence of *Salmonella* in foods, a sensitive and specific detection methods are needed.

Table 4: Presence of pathogenic bacteria In different categorized of RTE foods.

Type Of Food	Number Of Positive Sample		
	E. coli O157:H7	*Listeria spp.*	*Salmonella* spp.
Meat (n = 20)	2 (10.0)	ND	ND
Chicken (n = 30)	2 (6.7)	ND	ND
Fish (n = 22)	ND	ND	ND
Egg (n = 25)	2 (8.0)	ND	ND
Vegetable (n = 20)	1 (5.0)	1 (5.0)	ND
TOTAL (n = 117)	7 (6.0)	1 (0.9)	-

( ) - percentage
n - number of sample
ND - not detected in 25 g samples

CONCLUSION

It is concluded that microbiological quality of RTE foods sold in Kota Kinabalu areas were unsatisfactory and insist on the importance of hygiene measures through educational of street vendors to reduce the risk of foodborne diseases. The prevalence of certain pathogens such as *E. coli* and *E. coli* O157:H7 in ready-to-eat foods were significantly indicating a potential risk to health. Furthermore, this study also highlighted the importance of hygiene training course in improving the microbiological quality of foods sold.

ACKNOWLEDGEMENT

The authors wish to thank Mdm. Norlida Md Darus and all the staff from Kota Kinabalu District Health Office, Mr. Spencer Kan and staff from Queen Elizabeth Hospital, staff from Kota Kinabalu City Hall, laboratory assistance from University Malaysia Sabah and others who have directly or indirectly contributed in this project.

REFERENCES

Albrecht, J. A., Hamouz, F. L., Summer, S. and Melch, V. 1995. Microbial evalution of vegetable ingredients in salad bars. *J. Food Prot.* **58**: 683 – 685.

Arora, D.S. and Kaur, J. 1999. Antimicrobial activity of spices. *Intern. J. Food Microbiol.* **12**: 257-262.

Arumugaswamy, R. K., Gulum Rusul and Siti Nadzriah. 1994. Prevelence of *Listeria monocytogenes* in foods in Malaysia. *Int. J. Food Microbiology*. **23**: 117 – 121.

Baylis, C. L., MacPhee, S. and Betts, R. P. 2000. Comparison of methods for the recovery and detection of low levels of injured *Salmonella* in ice cream and milk powder. *Letter in Appl. Microbiology*. **30**: 320 – 324.

Charbonneau, D. L., Ponte, J. M. and Kochanowski, B. A. 2000. Method of Assessing the Efficacy of hand sanitizes: use of Real Soil Encounter in the Food Service Industry. *J. Food Prot*. **63**(4): 495 – 501.

Chiou, T.Y., Wang, M.Y. and Lin, A.Y. 1996. Sanitary indicator bacteria of the hot keeping cooked food items in Southern Taiwan. *Food Sci*. **23**: 909-912.

Cody, S.H., Glynn, M.K., farrar, J.A., Cairs, K.L., Griffin, P.M., Kobayashi, J., Fyfe, M., Hoffman, R., King, A.S., Lewis, J.H., Swaminathan, B., Bryant, R.G. and Vugia, D.J. 1999. An outbreaks of *E. coli* 0157:H7 infection from unpasteurised commercial apple juice. *Ann. Intern. Med.* **130**: 202-209.

Cutter, C. N. 1999. Antimicrobial effect of herb extracts agaist *Escherichia coli* O157:H7, *Listeria monocytogenes* and *Salmonella typhimurium* associated with beef. *J. Food Prot.* **63**(5): 601 –607.

Dkystra, J. J. and Schwarz, A. R. 1991. The race against germs. *School Food & Service Journal* **46**(6): 92,94,98.

Diane, R. 1995. *Practical Food Microbiology*. London: Public Health Laboratory Service.

Ehiri, J.E., Morris, G.P. and McEwan, J. 1997. A survey of HACCP implementation in Glasgow: is the information reaching the target. *Intern. J. Environ. Health Res.* **7**: 71-84.

Gohil, V. S., Ahmad, M. A., Davis, R. and Bobinson, R. K. 1995. Incidence of *Listeria* spp. in retail foods in the United Arab Emirates. *J. Food Prot.* **58**: 102 – 104.

Heinitz, M. L., ruble, R. D., Wagner, D. E. and Tatini, S. R. 2000. Incidence of *Salmonella* in Fish and Seafood. *J. Food Prot.* **63** (5): 579 - 592.

Hui, Y. H., Gorham, J. R., Murrell, K. D. and Cliver, D. O. 1994. *Foodborne Disease Handbook.* Vol. 1. New York: Marcel Dekker, Inc. 169 – 319, 345 – 395.

IFST. 1997. Development and use of microbiological criteria for foods. *Food Sci & Techno. Today* **11**: 137.

IFST. 1995. Scientific status summary: foodborne illness, role of home food handling practices. Institute of Food Science & Technology Expert panel on Food Safety. *Food Technol.* **49**: 119-131.

Jay, L.S., Comar, D. and Govenlock, L. D. 1999. Video Study of Australian Domestic Food-Handling Practices. *J. Food Prot.* **62** (11): 1285 – 1296.

Jackson, T., Mardin, M. and Acuff, G. 1996. Heat resistance of *Escherichia coli* O157:H7 in a nutrient medium and in ground beef patties as influenced by storage and holding temperature. *J. Food Prot.* **59**: 230 – 237.

Jameson, J. E. 1962. A discussion of the dynamics of *Salmonella* enrichment. *J. Hygiene*. (Cambridge) **60**: 193 – 207.

Joblonski, L.M. and Bohach, G.A. 1997. *Staphylococus aureus*. In. Doyle, M.P., Beuchat, L.R. and Montville, T.J. (eds). Food microbiology fundamentals and frontier. Washington: ASM Press: 353-375.

Kaneko, K.I., Hayashidani, H., Takahashi, K., Shiraki, Y., Limawongpranee, S. and Ogawa, M. 1999. Bacterial contamination in the environment of food factories processing ready-to-eat fresh vegetables. *J. Food Prot*. **62**:800-804.

KKCH. 2000. *Annual Report*. Kota Kinabalu City Hall, Sabah.

Litchfield, J. L. 1973. *Salmonella* and food industry – methods for isolation, identification and enumeration. *CRC Critical Reviews in Food Technology* **3**: 415 – 456.

Marshall, R. T. 1993. *Standard Methods For The Examination Of Daily Product*. 4th ed. Washington: American Public Health Association.

MOH. 2002. Food poisoning statistic. Communicable Disease Control Section, Ministry of Health Malaysia, Kuala Lumpur.

Mosupye, F.M. and Von Holy, A. 2000. Microbiological hazards identification and exposure assessment of street food vending in Johannesburg, South Africa. *Intern. J. Food Microbiol*. **61**: 137-145.

Mosupye, F.M. and Von Holy, A. 1999. Microbiological quality and safety of street vended foods in Johannesburg city, South Africa. *J. Food Prot*. **62**:1278-1284.

Restaino, L. and Wind, C. E. 1990. Antimicrobial effectiveness of hand washing for food establishments. *Dairy Food Environment Sanitation*. **10**: 136 – 141.

Sewell, A.M. and Farber, J.M. 2001. Foodborne outbreaks in Canada linked to produce. *J. Food Prot*. **64**(11): 1863-1877

Snelling, A. M., Kerr, K. G. and Heritage, J. 1991. The survival of *Listeria monocytogenes* on fingertips and factors affecting elimination of the organism by hand washing and disinfection. *J. Food Prot*. **54**: 343 – 348.

Snyder, O.P. 1998. Hand washing for retail food operations – a review. *Dairy Food Environ. Sanit*. **18**: 149-162.

Soriano, J.M., Rico, H., Molto, J.C. and Manes, J. 2000. Microbial evaluation of Spanish potato omelette and cooked meat samples in university restaurants. *J. Food Prot.* **63**(9): 1273-1276.

Uyttendaele, M., Troy, P-de. and Debever, J. 1999. Incidence of *Listeria monocytogenes* in different types of meat produced on the Belgium retail market. *Int. J. Food* Microbiology **53** (1): 75 – 80.

Wang, G.K, Yan, X., Feng, S., Chen, A.L. and Kokubo, Y. 1992. Isolation and identification of *L. monocytogenes* from retail meats in Beijin. *J. Food Prot.* **55**: 56-58.

WHO. 2000. *Who Responds to New Challenges In Food Safety*. World Health Organization. http://www.who.int/inf-pr-2000/en/pr2000-ot.html.