Food Contact Surfaces' Hidden Secrets and Food Handlers' State of Readiness

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Abstract

A guarantee for clean and safe food could be achieved when the standards of food hygiene at each preparation process and cooking practices are monitored and measured accordingly. This research examines the effectiveness of a self-regulatory practice in non-commercial residential establishments. The level of hygiene of cleaned food surface contacts was analysed through swab analysis. After a 24 hours incubation, the RIDA® count plates identified light blue colonies as total coliforms, demonstrating the existence of contamination across the majority of the selected food contact surfaces. This research, therefore, strongly encourage the application of a simple scientific tool to ensure accuracy and efficiency in the measurement of hygiene and sanitisation as it could affect the quality of life of the consumers.

Keywords: consumer quality of life; food hygiene; food surface contact; food handler; the on-site premise

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1.0 Introduction

In sustaining one's quality of life, the human body requires safe food to stay healthy and have energy. Thus we require food intake with clean and safe elements to prevent undesired health conditions. Hygienic and safe food is also crucial from a religious perspective. For instance, kosher food for the Jews and halal food for the Muslims. Kosher in the Hebrew Bible means "fit" and "appropriate". Halal is also a very crucial concept for all Muslims. In the Al-Quran, al Baqarah (Cow) verses: 58 and 169 emphasise on eating only good food: "Eat of the good things We have provided for you" and "O ye people! Eat of what is on earth, Lawful and good." The al-Baqarah verses 172 and 173 clearly state on the permissible and non-permissible food: "O ye who believe! Eat of the good things that We have provided for you, and be grateful to Allah, if it is Him ye worship. He hath only forbidden you dead meat, and blood, and the flesh of swine, and that on which any other name hath been invoked besides that of Allah. However, if one is forced by necessity, without wilful disobedience, nor transgressing due limits, - then is he guiltless. For Allah is Oft-forgiving Most Merciful." Both the Jews and Muslims are only allowed to eat permitted-food according to the guidelines given by their respective holy books. The Report Buyer (2017) reported that the Global Halal Market had projected to reach USD2.6 trillion for 2018 as the halal factor is now a trend for the tourism and hospitality industry. Over the years, the demand for halal food has increased tremendously as many tourists seek a guarantee for clean and safe food. The rising Muslim population has also influenced the increasing availability of halal products and services.

From the perspective of Act and Regulations, food consumers are protected by the 1983 Food Act (Act 281) in Malaysia. The Act consists of Food Hygiene Regulations 2009, Food Regulations 1985, and Food Regulations 2009 (issuance of health certificate for export of fish and fish products to EU). Besides, food standards are made available the ISO 22000:2012 (Food Safety Management), MS1500:2009 (For Halal Food), MS1480 (Food Safety according to Hazard Analysis and Critical Control Points (HACCP)), MS1514 (Good Manufacturing Practice for Food), just to mention a few. They serve as practical guidance for the food sector. Among all, MS1500 is the food safety management system (FSMS) that covers various aspects of Good Manufacturing Practice (GMP) and HACCP. To date, three levels for Malaysia's food safety certification have been established; the FSMS, HACCP, and GMP. Other than these, there are also other self-voluntarily programs such as Good Handling Practices or Good Hygiene Practices (GHP), GMP, and HACCP in food factories.

1.1 Problem Statement

The Ministry of Health under the Food Quality Control Division Food conducts premise inspections on hygienic matters. As the food industry is now expanding aggressively, the industry can no longer depend only on enforcement staff from the local health authorities. In October 2018, the Malaysian Department of Statistics reported that the Industrial Production Index (IPI) increased by 4.2 per cent compared to the same month of the previous year. The IPI is mainly supported by manufacturing where food, beverage and tobacco contributed 2.6 per cent of the overall manufacturing indices.

Food business operators, therefore, opt for a self-regulatory procedure and take full responsibility for monitoring the hygiene standards of their operations. This procedure aligns

with the hygiene inspection checklist which is now widely implemented mainly in the operation of a kitchen in schools. Kitchen managers use the checklist to check if utensils are clean and safe for use. Professional kitchens of small and medium-sized businesses such as catering, mobile food operators, and restaurants also use this self-monitoring system as recommended in the HACCP. The bureaucratic and product-specific HACCP system is scientifically-based and follows a systematic concept to determine specific sources of hazards to control and ensure the safety of foodstuff.

HACCP also requires a set of practices for incoming goods inspection, temperature monitoring, pest control, staff training, and hygiene plan. The hygiene or cleaning plans consist of disinfection measures for all operational areas including sales, production, and storerooms. This in-house practice is not only cost-effective but also flexible for integration into an existing quality management system. As such, its good practices must be documented, and the outcomes are recorded and checked at several intervals as a way of measuring continuous improvements.

The checklist also includes a record of what is cleaned, how frequent, what with, by whom, how, and when for traceability purposes. Despite transparency in record keeping, there is no certainty that the food service establishment is carrying out self-monitoring adequately. Similarly, attending a compulsory food handling course or getting a typhoid injection would not guarantee that a food operator is competent in conducting self-regulatory checks.

Moreover, in 2011, 3.52% out of 98,308 premises inspected were found to be unsanitary. Accordingly, they were closed under Section 11, Food Act 1983 (MOH, 2011). These incidents trigger this research with a question if the on-site premises are ready for self-regulatory practices.

1.2 Objectives of the Study

The primary purpose of this research is to find out if Malaysian food handlers at on-site premises are ready for self-regulatory practices. To achieve this, it assumes that food handlers in government-controlled food establishments have sufficient knowledge and awareness of good hygiene and practices. Information on food contact surfaces was therefore obtained from these sites to gauge the status of their food hygiene practices and their level of readiness for self-regulatory inspections.

2.0 Literature Review

2.1 Food Contact Surface

The food contact surface is known as the leading cause of foodborne viruses as improper handling practices during the cleaning or handling of food may cause food contamination that could potentially be risky to public health. Food contact surfaces refer to surfaces that consist of pathogenic microorganisms that are in direct contact with food. Ismail et al., (2017) reported that most of the outbreak of foodborne illness associated food contact surface where

the bacterial cross-contamination or recontaminationoccurred. Thus, it is necessary to reduce the number of pathogenic and food spoilage microorganism to acceptable levels by proper and diligent sanitation of food contact surface to avoid the incident of foodborne illness outbreak (Begani et al., 2012). According to Knechtges (2012), frequent sanitation is an effective way to control and ensure the safety of foodstuffs.

The types of contact surface may contribute as one of the factors of cross-contamination of foodstuffs with the microorganism. Although the food contact surface may not be a source of contamination, the chances for cross-contamination among surfaces may exist because of lack of surface separation as well as shortcomings in cleaning management (Nhlapo et al., 2014). On the other hands, distorted surfaces could provide shelter for microorganisms to thrive. The use of wood as utensil has decreased during the last 20 years because it is difficult to clean due to its porosity. Therefore, other materials such as plastic and stainless steel have taken in their place in the food industry. However, the study by Ismail et al., (2017) showed that wood did not impact food safety if correct and sanitation of the wooden shelves was performed. It is suggested, a proper procedure of cleaning and sanitation must be followed to minimise the cross-contamination or recontamination of foodstuffs.

2.2 Pathogenic Bacteria

Foodborne illnesses are usually caused by food handler hands since they are in regular contact with pathogens that are available in the surrounding environment (Hawker et al., 2012). Pathogenic bacteria can be transmitted at any stage of food preparation, as well as in the kitchen due to improper handling (European Food Safety Authority, 2014). Moreover, the most common source of contamination would be the food handlers themselves because they can spread pathogenic organisms via a faecal-oral route or skin lesions and the use of dirty kitchen utensils or kitchen counters (Linscott, 2011). Several types of pathogenic microorganisms such as *Escherichia coli*, *Salmonella, Shigella*, and *Staphylococcus* are the most common microbiological hazards that cause gastroenteritis (Loukieh et al., 2018). *Bacillus species* (for example *Bacillus subtilis*) is identified as the most pathogenic bacteria from aerobic growth isolates of food contact sources (Sibanyoni & Tabit, 2019). Poor hand hygiene might contribute to high levels of *S. aureus* and *E. coli* on the hands of food handlers.

Lack of personal hygiene among the food handlers, unclean environment and water supply are known factors that contribute to foodborne illnesses (Meftahuddin, 2002). Kitchen utensils also are one of the possible factors that lead to bacterial contamination on foodstuffs (Ayçiçek et al., 2004). A study by Nhlapo et al., (2014) reported that preparation surfaces enumerated the highest counts of total coliforms, *E. coli*, and *S. aureus*, with aprons yielding the highest count of yeast and moulds, while hands had the lowest count of these organisms. However, Baghapour et al., (2015) reported that work surfaces such as cutting board, table, and hand, showed acceptable contamination about the enumeration of total bacterial count and coliform in comparison to the standards. In short, it is necessary for food handlers to implement safe management of the kitchen, educate themselves and also improve the usage of equipment.

2.3 Foodborne Analysis

Foodborne illness has been associated with the ingestion of pathogenic bacteria such as *Salmonella Typhi, Escherichia coli, Staphylococcus aureus, Vibrio cholera, Campylobacter jejuni,* and *Listeria monocytogenes* (Abdul Mutalib et al., 2015). Pathogenic bacteria can be transmitted at any stages of food preparation including contamination at the farm, during slaughtering where meat has been contacted with animal intestine, fur or skin and in the kitchen during food preparation due to improper handling (European Food Safety Authority, 2014). Lack of personal hygiene of food handlers, unclean environment and water supply is known to be the factors that contribute to foodborne illnesses (Meftahuddin, 2002). However, the most common source of contamination would be food handlers because they can spread the pathogenic organisms via a faecal-oral route or skin lesions, and through the use of dirty kitchen utensils or kitchen counters (Linscott, 2011). Food premise inspection is crucial to ensure the level of hygiene in food premises (Abdul Mutalib et al., 2015). Food samples have been collected from various food premises to determine whether the food service provider prepare food according to the accepted requirement by the Ministry of Health Malaysia.

2.4 Prerequisite Programs Implementation at On-site Food Services

Ensuring food safety is critical for the food service operation to prevent the outbreak of foodborne illness. Several factors contributed to the outbreak of foodborne illnesses. Many studies reported that the primary cause of the outbreak is usually associated with inadequate handling of food which involved cases such as inadequate cooking temperature and storage and cross-contamination between raw foods and ready prepared food (Greig et al., 2007). Moreover, as reported by Egan et al., (2007), food handlers are estimated to cause almost 97% of cases of foodborne outbreaks. Thus, it is essential for food handlers to have good practices for food handling and they are expected to practice it in their work environment. Therefore, an intervention program based on the knowledge, attitude and practice triad is important to improve the sanitation and hygiene condition regarding structural issues, controls and records and food handling activities which are essential for quality assurance (da Cunha et al., 2013).

It is suggested for foodservice operators to implement a prerequisite program to prevent the outbreak of foodborne illness. Prerequisite program procedure usually involves the standard operating procedure, sanitation and hygiene procedure and procedure for receiving and storage of foods. However, as reported by Martis and Rocha (2014), cleaning and sanitising procedure, temperature control and waste management are the most challenging elements for prerequisite programs implementation at the food service in schools. Therefore, regular observational supervision of activities, continuous training of workers and surveillance of high-risk cross contamination surface should be implemented to ensure food safety in catering services (Garayoa et al., 2017).

3.0 Methodology

In this research, the on-site premises' readiness for self-regulatory practices among food

handlers is investigated by using the food contact surface as an indicator that determines the effectiveness of both the cleaning and sanitation procedures. This research identified 17 government-controlled on site-premises in Selangor and Perak. Using purposive sampling, the investigation of food contact surfaces was done at six government-controlled on-site premises as recommended by the Malaysian Ministry of Health.

3.1 Swab Analysis Procedures

There are two types of swab methods; conventional and unconventional. The conventional method is recommended for application in field studies or food safety management protocols in the industry as it can detect pathogenic bacteria (ISO 18593, 2004). A sterile cotton swab with an applicator stick for releasing microorganisms from the surface is generally used in the conventional swabbing procedure (Pérez-Rodríguez et al., 2008), while an unconventional swab uses a calcium alginate swab bud which dissolves directly in the culture medium and is much more accessible than the conventional service method (Miller, 1996). As for this research, swab analysis used Rida@count to test the presence of protein on cleaned food contact surfaces.

In this microbial investigation, the food contact surfaces for sampling were in critical areas of the intermediate and final processes of the food service operation as suggested by "a Guide to Environmental Microbiological Testing for the Food Industry" (2008). It was suggested higher weighing should be given to areas which involve dirtier activities that are in close relative proximity to clean areas, often wet areas, open drains areas, and areas that have high levels of staff activity.

3.2 Material and Method

Food contact surfaces in this research refer to the dining table top, cutting knife, food serving tray, cooking pot, and spatula. Of the selected five samples, 90 samplings were planned for 180 samplings examination, in which the total coliforms were isolated from the same source of the sample. These surfaces were swabbed with RIDA@count for hygiene monitoring of sanitation programs. Microbial colonies were counted as Colony Forming Units (CFU)/cm^2 that later were computed in $\log_{10}$ CFU/cm^2. This research adopts techniques used by Saad et al. (2016); they used the RIDA Count® in their study as addition to a Colilert Test to determine the cleanliness of food contact surface after regular cleaning. Their results showed that all food contact surfaces (dining table tops, food trays, cooking pots and kitchen faucets) had the highest coliform contamination. The same technique is therefore applied in this research to detect possible pathogen microorganisms that would reflect the food hygiene practices of on-site premises.

During the swabbing process, the selected utensils were placed on the dining table top that already had the disinfection procedures before sampling activities. Later, all samples were aseptically placed into the cool box with dry ice packs and brought to the laboratory. The temperature was maintained to be in between 0º to 4ºC to preserve the integrity of the sample, i.e. bacterial numbers should remain constant until the sample can be evaluated. For microbial enumeration, each sample was incubated at 35°C for 24 hours

for bacterial colonies of total coliforms. After 24 hours, the RIDA® count plates identified light blue colonies as total coliforms. As mentioned earlier, colonies were counted as CFU/cm^2 and expressed in log_{10} CFU/cm^2.

4.0 Findings

Chi-Square analysis was used for accessing the existence of total coliforms of the specific surfaces in this research that were taken from six selected Non-Commercial Residential Establishment as suggested by Field (2009), Agresti (2007), and Daniel (1990). According to them, this analysis technique is a suitable technique since the measurement taken for the targeted variables (i.e. Existence of total coliforms vs Non-commercial Residential Establishments) were in terms of categorical data. Two categories were used for measuring the existence of total coliforms (i.e. Exist or Don't Exist), whereas six categories were used to reflect the six targeted locations of the Non-Commercial Residential Establishments in Malaysia.

In addition, combination of the Likelihood Ratio Test and Fisher's Exact Test were used for getting more consistent results (i.e. not too much deviant) of the Chi-Square value, as well as the probability value since the sample size for this research, can be considered as relatively small (Field, 2009; Agresti, 2007; Daniel, 1990). It can be considered small since only three replications were used for measuring the existence of total coliforms in the targeted contact surface due to the time and cost constraints.

Table 1: Likelihood Ratio and Fisher's Exact Tests on Existence of Total Coliforms of Selected Contact Surfaces across Non-Commercial Residential Establishments

Contact Surface	Likelihood Ratio Test	Fisher's Exact Test
Food Serving Tray	15.276* (p = .009)	9.893* (p =.026)
Spatula	20.238* (p = .001)	12.833* (p = .006)
Cooking Pots	15.276* (p = .009)	9.893* (p =.026)
Cutting Knife	8.739 (p =.120) (NS)	6.548 (p = .118) (NS)
Dining Table Top	8.739 (p =.120) (NS)	6.548 (p = .118) (NS)

Note: p = Probability value; NS = Not SIgnificant; Degrees of Freedom = (Row-1)*(Column-1) = 5*1 = 5; *p <.05.

The existence of the total coliforms was found at the Dining Table Top and Cutting Knife contact surface across six selected Non-Commercial Residential Establishments (i.e. Refers to Figures 1 and 2). However, the total coliforms existence was not statistically significant from the perspective of Likelihood Ratio Test and Fisher's Exact Test (Dining Table Top & Cutting Knife: Likelihood Ratio: 8.739, p =.120; Fisher's Exact Test: 6.548, p =.118). In contrast, both tests confirm that the existence of the total coliforms significantly existed at

Food Serving Tray, Cooking Pot, and Spatula contact surface across the six selected Non-commercial Residential Establishments since the probability values for both tests was significant for at least 95% confidence level.

Regarding the existence of the microbe at the Food Serving Tray contact surface, Figure 3 indicates that total coliforms existed at X5, X4, and X3 Non-commercial Residential Establishments, whereas X6 Non-commercial Residential Establishment indicates that the microbe could be assumed as non-existent based on the three replication samples. However, for X2 and X1 Non-commercial Residential Establishments, the existence of total coliforms could be described as mild since around one to two replication samples indicated the existence of this microbe. As for the existence of the total coliforms at the Cooking Pot contact surface, Figure 4 confirms that the microbe existed throughout the Cooking Pots of X4, X5, and X6 Non-commercial Residential Establishments, but not at X1 Non-commercial Residential Establishment. The analysis also indicates that the total coliforms were at a mild level for X3 and X2 Non-commercial Residential Establishments. Concerning the Spatula contact surface, Figure 5 confirms that this microbe existed on all Spatula contact surfaces of X3, X4, and X6 Non-commercial Residential Establishments. Nevertheless, the existence of this microbe can be described as null for X6 and X2 Non-commercial Residential Establishments. Also, X1 Non-commercial Residential Establishment indicates that the existence of this microbe was at a mild level since only two replication samples indicated the existence of this microbe.

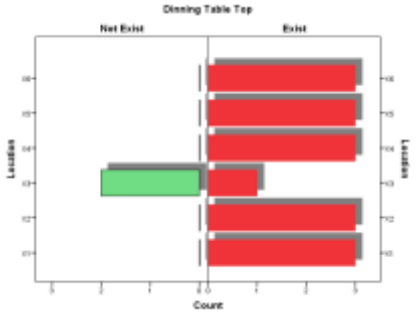

Figure 1: Cross-tabulation Analysis of Existence of total coliforms at Dining Table Top across Six Selected Non-commercial Residential Establishments

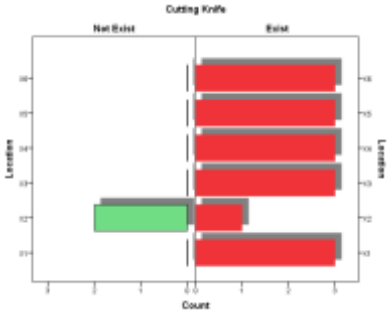

Figure 2: Cross-tabulation Analysis of Existence of total coliforms at Cutting Knife across Six Selected Non-commercial Residential Establishments

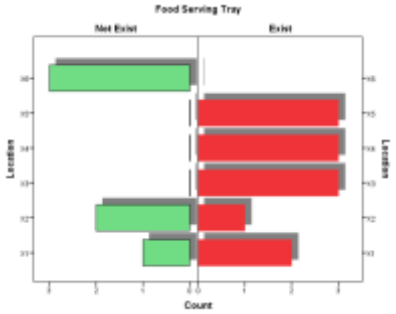

Figure 3: Cross-tabulation Analysis of Existence of total coliforms at Food Serving Tray Top across Six Selected Non-commercial Residential Establishments

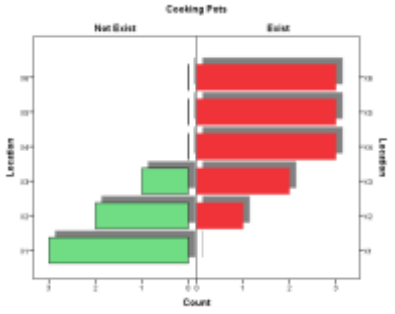

Figure 4: Cross-tabulation Analysis of Existence of total coliforms at Cooking Pots Top across Six Selected Non-commercial Residential Establishments

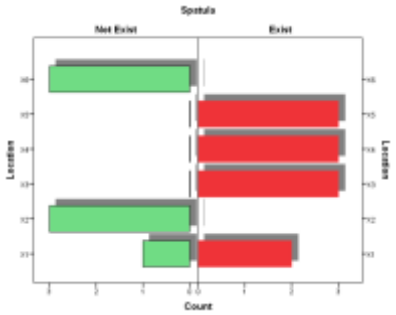

Figure 5: Cross-tabulation Analysis of Existence of total coliforms at Spatula across Six Selected Non-commercial Residential Establishments

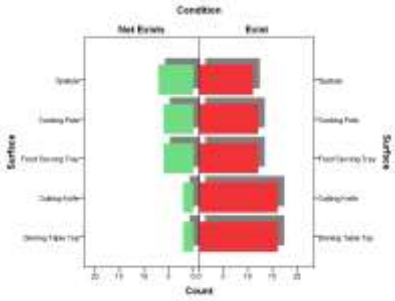

Figure 6: Cross-tabulation Analysis of Existence of total coliforms and Contact Surface

Table 2 shows the results of Likelihood Ratio and Fisher's Exact tests for assessing the significance of differences in the existence of total coliforms across the selected five contact surfaces of the six selected Non-Commercial Residential Establishments groups. The result in this study indicates that there is no significant difference in terms of the existence of the total coliforms towards these selected five contact surface (Likelihood Ratio: 7.302, p =.121; Fisher's Exact Test: 6.779, p =.133). Besides that, it is also aligned with Cross-tabulation result presented in Figure 7, where the existence of total coliforms can be considered to exist at all selected five contact surfaces.

Table 2: Cross-tabulation Table, Likelihood Ratio Test and Fisher's Exact Test on Existence of Total Coliforms across Types of Contact Surfaces

	Contact Surface				
Condition	Dining Table Top	Cutting Knife	Food Serving Tray	Cooking Pots	Spatula
Exist	16	16	12	12	11
Not Exist	2	2	6	6	7

Note: Likelihood Ratio Test = 7.302, p = .121; Fisher's Exact Test = 6.779, p =.133; Degrees of Freedom = (Row-1)*(Column-1) = 4*1 = 4.

5.0 Discussion

Food contact surfaces which include a dining table, knife and cutting board are the potential sources of contamination in any foodservice establishment. Hence, the material selected for food contact surface must be smooth, non-porous, and durable to support many sanitation processes. Sanitation that consists of cleaning and disinfection is the primary control measure for microbial contamination. Effective sanitation process has been proven to lower the risk for food contact surface contamination.

This study was conducted with aims to provide an empirical result on the presence of coliform on food contact surfaces in the selected Non-commercial Foodservice Establishments. The results provide significant information on the level of total coliform contamination on the surface of Dining Table, Cutting Knife, Food Serving Tray, Cooking Pot and Spatula which may verify if the sanitation process has been carried out adequately or not. From the results obtained, it was found that the coliforms do present on Dining Table and Cutting Knife surfaces ($p > 0.05$). Whereas, the range of 'not exist to exist' coliforms is found on the Food Serving Tray, Cooking Pot and Spatula surfaces across the six Institutional Foodservice Establishments studied. In total, coliform contamination is found on the majority of the selected contact surfaces studied, although, between the Non-commercial Residential Establishments, the contamination is not significant.

The results reveal that coliform pathogenic microorganisms contamination take place on the food contact surfaces of Non-commercial Foodservice Establishments studied which may lead to cross-contamination occurrence. Improper hygiene and handling procedures may cause foodborne disease outbreaks. Foodborne disease outbreaks, do not only contribute to consumers' health problem but also nations substantial economic consequences. Existing coliform in any foodservice establishment is a severe microorganism's infection since it indicates that vast improvement in safe food handling practices is critically in need. Also, the coliform contamination detected in this study was encountered in the Non-commercial Foodservice Establishments where foods were prepared for the teenagers in the range of 17 to 20 years old with some of them possibly with a weak immune system. Hence, the pathogenic microorganism contamination found on food-contact surfaces may increase the

risk of cross-contamination into the food offered to this group of people. Contamination of coliform on food contact surfaces being encountered in almost all of Non-commercial Foodservice Establishments studied, indicating that coliforms are present at everywhere in the kitchen included in the well equipped and with a great variety of utensils.

Coliform is a Gram-negative non-spore forming bacteria within the family of Enterobacteriaceae that can survive with or minimal amount of O2 at the optimal growth temperature of 35 to 40°C. Coliform existing in any food contact surfaces is associated with secondary contamination due to improper processing procedures and poor personal hygiene practices. Furthermore, it is also commonly related to an inadequate and ineffective sanitation program applied in any related food establishments (Ali & Immanuel, 2017; Nhlapo et al., 2014). However, the presence of coliform always reflects the bad attitude and practices among food handlers where coliforms which include E. coli are the microorganisms that can be found abundantly in the humans and animals intestinal tract. It is in agreement with Pepper and Gerba, (2009) where the presence of total coliform in food indicates typically faecal contamination. While in the study by Gorman et al. (2002), they revealed that there was a significant relationship between food contact surfaces and food handlers' proper hygiene practices where hand that had gone through improper hand washing procedure are reported to be significant vehicles for pathogenic bacteria including coliform and significantly contribute to cross-infection thus increasing the transfer of pathogenic microbial into food. It is being reported that approximately 97% of foodborne illnesses in food service establishments and homes is related to improper food handler hygiene practices.

Theoretically, food handler's proper hygiene practice significantly reduces the potential of microbial contamination in a food establishment. Attending any courses related to good hygiene practices is one of the ways to such information. In general, the food handlers who continuously receive training tend to display better hygiene awareness and food safety handling practices.

Coliform was reported to be present in warm-blooded animals and other organisms often located on the ground or plants (Antonio Valero, 2016). The Non-commercial Foodservice Establishments selected for this study were based in a countryside area where environmental contamination from birds, rodents, flies and cockroaches are possibly very high. Nielsen et al. (2004) in their study stated that wild birds and rodents that abundantly found in rural areas carry along a relatively significant amount of disease-causing and toxin-producing pathogen. Furthermore, changes in environmental factors such as weather and relative humidity during transportation may manipulate and encourage the growth of microbial hazards (Newell et al., 2010). Moreover, the changes may also influence the current and future deficiencies in any Non-commercial Residential Establishments, such as watershed protection, infrastructure, and drainage systems, thus increasing the risk of coliform contamination.

Also, Nhlapo et al. (2014) reported that contaminated water usage and mishandle in sanitation methods of food contact surface that include incorrect dilution factor of detergent or inadequate contact time, as well as lack of proper kitchen facilities and ventilation might also contribute to contamination of food contact surfaces. Therefore, the food contact surfaces need to be cleaned and sanitised thoroughly to reduce the number of pathogenic bacteria to an acceptable level since proper cleaning and disinfection procedures positively

control the microbiological growth.

6.0 Limitation of Study

One of the limitations, this research does do not cover the big cooking pots inside the kitchen as they were all in use during the visit (Figure 7).

Figure 7: Sample of Big Cooking Pots in the Kitchen

7.0 Conclusion and Recommendations

This research has used crucial data obtained from food contact surfaces of on-site premises to translate several issues related to food handlers' competency and readiness for self-regulatory monitoring of their food-hygiene practices and standards. The study concludes that food contact surfaces are the most likely vehicle for the transmission of contaminated food and infectious diseases in our world today. With the presence of contamination on most of the contact surfaces studied and the high risks placed on public health and safety resulting from cross-contamination to food service, this research highlights the need for higher food handling practices and standards as well as continuous training and upgrading of relevant skills for those involved in the food industry.

The study recommends the application of a simple scientific tool to ensure accuracy and efficiency in the measurement of hygiene and sanitisation, while all the results should also be recorded and traceable for the Health Ministry's audit inspection. At the same time, field studies are encouraged to compare the tool used in this research with other similar tools so that foodservice operators have a range of choices at their disposal. As the Malaysian government is encouraging a self-monitoring food system at schools, programs providing food to our children would benefit from the hygiene standards and practices expounded in this research. The investigation of self-regulatory hygiene practices with accurate results is therefore vital for the future of food establishments and the food handlers' profession in the industry.

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