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FULL PAPER

Preliminary screening and microbiological evaluation on the environmental hygiene for galley equipment, safety equipment and cabin common facilities of a local airline in Malaysia

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Abstract

Over the last two decades, only a handful of research have been conducted pertaining to food safety in the aviation industry. The gap of knowledge in in-flight food safety literature has long been silenced. Therefore, it was the objective of this study to conduct preliminary screenings to evaluate the environmental quality of the service equipment (GE), safety equipment (SE) and common facilities (CF) within the confinement of commercial aeroplanes in Malaysia. A total of 112 swab samples (n = 112) were analyzed to detect the prevalence of *Escherichia coli*, *Vibrio*, *Salmonella* and coliforms using conventional microbiological methods. The qualitative aerobic mesophilic plate count revealed that 99 (88.39%) and 13 (11.61%) were reported as positive and negative samples, respectively. It was reported that all 17 samples taken from the long-haul flight were positive, with 8 (9.14%), 4 (3.57%) and 5 (4.46%) samples belonging to the GE, SE, and CF, respectively. Forty-five positive swab samples taken from medium-haul flight sectors showed that 30 (26.79%), 8 (9.14%), 7 (6.25%) samples were that of the GE, SE, and CF, respectively. Meanwhile, 19 (16.96%), 8 (9.14%), and 10 (8.93%) of the short-haul flights samples were that of the GE, SE, and CF, respectively. It was therefore concluded that GE, SE and CF were reported at 57 (50.89%), 20 (17.86%) and 22 (19.64%), respectively. In view of the large numbers and high percentages of positive sample results, it is our opinion that the cleaning, sanitizing and disinfecting procedures of the galley equipment, safety equipment and common facilities are revisited. The assurance in conformance to the hazard analysis and critical control points (HACCP) management system may enhance the safety and reliability of all stakeholders especially the flight attendants who are the final custodians of the environmental hygiene and that of themselves.

1. Introduction

The odds of having difficulty conducting research in the confinement of commercial aeroplanes that fly 35,000-40,000 feet above sea level is undeniably high. Such difficulty may be contributed and limited by stringent regulatory requirements that govern the security and safety of the aviation industry. Therefore, as industrial skilled players, this study presented a rare opportunity which was aimed to conduct preliminary screenings that determine the microbial quality of galley equipment, safety equipment and common facilities of aeroplanes operated by a local airline in Malaysia.

The aerobic mesophilic plate count is a conventional method of microbial analysis to estimate the presence of cells based on their ability to give rise to colonies under specific conditions of nutrient medium, temperature and time. It is also intended to indicate the level of microorganisms in a product. It is considered the most

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widely used technique or tool for evaluating microorganisms in foods (Brackett, 2014). Whichever method is selected or used to achieve the primary purpose of analysis may be subjected to accuracy, reproducibility, reliability, specificity, and sensitivity (Tunung *et al.,* 2012). Therefore, it is also necessary to conduct aerobic plate count as it indicates the level of microorganisms in a product (Maturin and Peeler, 1998). According to Saarela (2007), the plate count technique is based on the reproduction of bacterial cells on agar plates. The plate count technique is the traditional method used for the quality assurance of probiotic products. Even though this method provides information about the microbial load in food samples, it is not without any limitations. The first drawback is that the standard plate count only tells how many cells are but not what kind of cells are present. Secondly only relatively rapidly growing aerobic organisms such as bacteria are enumerated (Brackett, 2014). On one hand, aerobic mesophilic plate counts (AMPC) are considered poor indicators of food safety in many cases because they do not directly correlate to the prevalence of pathogens or toxins. While on the other hand, subject to the condition of the product, AMPC can be valuable in accessing the microbial quality and organoleptic acceptability of foods (Pianetti *et al.,* 2008). Therefore, conditions used in standard plate count may not be able to enumerate many fungi and as a result other important organisms, intended or otherwise, are missed out by this procedure.

Interestingly, various studies reported that pH (Therion *et al*., 1982; Cole *et al*., 1990; Presser, 1997; Koutsoumanis *et al*., 2004) and temperatures may have influenced the growth limit of pathogenic bacteria (Rocourt and Cossart, 1997; Shachar and Yaron, 2006; Gandhi and Chikindas, 2007). Kim *et al.* (2018) postulated that the optimal levels for bacterial growth rate were at pH 9 and 35˚C. These 2 factors will determine the growth rate and responsiveness of microorganisms.

Russell (2005) was using the standard plate count method for enumerating microorganisms from food samples based on the presumption that organisms are able to multiply in cultural media containing agar to form colonies. It is also assumed that each colony-forming unit (CFU) represents a single bacterium that has grown in or on the medium in question. Given exposure to appropriate temperature and atmosphere, the mass of cells is produced and can be observed by sight so that the colonies can be counted.

The galley equipment (GE), safety equipment (SE) and common facilities (CF) are regularly utilized in the course of handling and serving food as well as replenishing amenities in the cabin common facilities onboard the aeroplane. These processes are undoubtedly exposed to a high potential of direct contamination and other cross-contamination factors. Such adulterated conditions serve as possible food contamination that leads to food poisoning.

The results of this study should be able to capture the awareness of the importance of microbial quality evaluation because it is closely associated with food handling hygiene and food handling practices among flight attendants. To the best of our knowledge, this is the first study of its kind and of which the outcome can be used as a baseline reference for future research development. Therefore, this study was a novel attempt to fill the missing gap of knowledge on such a setting in the Malaysian aviation industry.

2. Materials and methods

2.1 Samples collection

A total of 112 swab samples (n = 112) were collected from five selected inbound flight sectors in accordance with the aircraft types and flight time range. Table 1 entailed details of swab sample distribution. Upon arrival at Kuala Lumpur International Airport, the targeted swab samples were immediately transported to the Food Safety and Quality Laboratory at Food Science and Technology faculty, UPM Serdang. Each cotton swab was placed individually in a small sterile zip-type transparent polyethylene plastic bag, 30×60 mm. All of the individually packed swab samples were kept cool in another large sterile double zipper transparent plastic bag, 144×160 mm. The large sterile plastic bag was placed in a mini cooler bag and transported to the laboratory within 4 hrs upon arrival of aeroplanes at Kuala Lumpur International Airport.

2.2 Microbiological analysis

Mesophilic aerobic bacterium; *Escherichia coli, Vibrio, Salmonella* and coliforms were enumerated using the conventional method (Morton, 2001). Buffered peptone water (BPW) (Oxoid, UK), measured and poured into 10 mL universal bottles as per quantity required and was autoclaved at 121˚C for 15 mins. The cotton swab samples were cut at both ends and placed into the prepared sampling bottles. Every sample was briskly shaken to harmonize the diluent before being incubated at 37˚C for 24 hrs. The incubated swab samples were then streaked onto respective agar plates and incubated at 37˚C for another 24 hrs. The agar plates were inspected for any microorganism growth. Plates that showed any form of prevalence growth were noted as positive samples while agar plates that did not show

Table 1. The galley equipment, safety equipment and common facilities selected for surface swab samplings

No	Items identification	Distribution of items				
		Flight Category	Short haul BKI/KUL	Medium haul BOM/KUL	Long haul LHR/KUL	Medium haul NRT/KUL	Short haul SUB/KUL
1	Latches	Galley Equipment (GE), n = 64				22	14
2	Ovens			2	8	4	4
3	Wine Chillers			2		1	
4	Galley Worktops			2		1	
5	Water Boiler Faucets					2	2
6	Lavatories	Cabin Facilities (CF), n = 28	14	7	5		
7	Passengers Chair-table						2
8	Crew Seatbelts	Safety Equipment (SE), n = 20		6			2
9	Crew Bunks				2		
10	Door Handles						
11	Handsets			2			2
12	Arming Levers				2		2
13	Door Girt Bar						2
Total			14	21	17	30	30
Cumulative Total samples					112		

GE: Galley equipment, SE: Safety equipment, CF: Common facilities, i.e. lavatories

any microorganism growth were denoted as negative samples. Microsoft Excel 2010, Version 14, was used to calculate the frequencies and percentages of the microbial results.

2.3 Flight sectors selection

Five inbound flight sectors into Kuala Lumpur International Airport, KLIA were selected. One of which was an inbound long haul sector from London Heathrow International Airport. This flight sector was operated by Airbus A350-900. Two medium-haul flight sectors; an inbound sector from Mumbai (India) and another inbound sector from Narita, Tokyo (Japan) were also selected. The flight from Mumbai was operated by Airbus A330-200 and the sector from Narita was operated by A380-800. Similarly, 2 short-haul flight sectors; one international flight originated from the Surabaya sector which was flown using Boeing B737-800 and one domestic flight sector which was flown by A330-200 from Kota Kinabalu, were inclusively selected for these preliminary screening microbial analyses. Table 2 illustrates the flight sector selections.

Table 2. Inbound flight sectors selected for the preliminary screening analyses

Type of flight sector	Country of origin	Sector	Aircraft type	Flight category
Short haul	Malaysia	BKI/KUL	A330-300	Domestic
Medium haul	India	BOM/KUL	A330-300	International
Long haul	United Kingdom	LHR/KUL	A350-900	International
Medium haul	Japan	NRT/KUL	A380-900	International
Short haul	Indonesia	SUB/KUL	B737-800	International

BKI: Kota Kinabalu International Airport, Malaysia, KUL: Kuala Lumpur International Airport, Malaysia, BOM: Charapathi Shivaji International Airport, Mumbai, India, LHR. London Heathrow International Airport, United Kingdom, NRT: Narita Tokyo International Airport, Japan, SUB: Juanda International Airport, Surabaya, Indonesia

3. Results

3.1 Microbial preliminary screening result for the selected inbound flight sectors.

After the incubation period of 48 hrs, the aerobic mesophilic agar plates were inspected for microbial growth of the selective microorganism indicators. On 16th July 2018, an Airbus A330-300 was used to fly the passengers across the South China Sea from Kota Kinabalu (BKI) into Kuala Lumpur (KUL). Such a flight sector was considered a rushing flight sector because the flight time was scheduled at 2 hrs 15 m. Taking into account that this flight sector was a short-haul flight, time was the indefinite constraint, therefore, only the common facilities were sampled for microbial analysis. According to Table 3, the preliminary screening results reported that 8 samples were positive and 6 samples were negative.

In addition, 21 samples were collected from a medium-haul flight sector that originated from Mumbai (BOM), India on 28th July 2018 which travelled using A330-300. The swab samples were taken from 6 galley equipment, 7 safety equipment and 8 cabin common facilities. As indicated in Table 3, it was reported that all of the 21 samples were reported as positive. Similarly, Table 3 also reported that the preliminary screening results indicated that all 17 samples sampled from a long

haul flight originating from Heathrow London were positive. This flight took off from London, (LHR), the United Kingdom, on 30th July 2018 travelled using A350 -800. The swab samples were taken from 8 galley equipment, 4 safety equipment and 5 cabin common facilities.

Narita Tokyo (NRT) was another inbound medium-haul flight that departed from Japan. This flight was operated by the superjumbo Airbus A380-800 on 10th October 2018. A total of 30 swab samples were taken from galley equipment only. The preliminary screening schedule in Table 3 showed 24 samples were positive. Only 6 samples were reported as negative. The 5th microbial preliminary screening analysis in which another 30 samples were sampled from Surabaya (SUB), Indonesia to Kuala Lumpur (KUL), was a short-haul inbound flight sector. Twenty swab samples were taken from galley equipment, 8 safety equipment and 2 cabin common facilities. The aircraft designated for this flight was a narrow-bodied aeroplane with a single aisle, Boeing B737-800. Table 3 showed only one sample was reported negative while 29 samples were observed as positive. The positive samples of the galley equipment, safety equipment and common facilities were reported at 19, 8 and 2 samples, respectively.

With reference to Table 4, it was concluded that the positive samples of the long haul flight were reported at 17 samples. These samples of 8 (7.14%), 4 (3.57%) and 5 (4.46%) were that of the GE, SE and CF, respectively. The medium flight sector category showed 45 positive samples. The results of 30 (26.79%), 8 (7.14%) and 7 (6.25%) positive samples were that of the GE, SE and CF, respectively. Short-haul flight sectors showed 19 (16.96%), 8 (7.14%), 10 (8.93%) positive samples of the GE, SE and CF, respectively.

4. Discussion

An agar plate was considered as a positive sample if visible microorganism growth was detected. When no visible microbial growth was detected, then the plate count was counted as a negative sample. Table 3 illustrates that the short flight sector from Kota Kinabalu (BKI) showed 8 positive and 6 negative samples. The 21 and 17 samples taken from a medium-haul flight sector Mumbai (BOM) and a long haul flight London (LHR) were denoted as all positive. The 24 samples derived from another medium flight sector from Narita, Tokyo were positive. Lastly, the results from another short-haul inbound flight sector from Surabaya produced 29 positive samples. Therefore, it was concluded that the preliminary microbial screening results showed that 99 (88.39%) of the swab samples were denoted as positive with at least one microbial indicator and 13 (11.61%) were negative swab samples free from all of the microbial indicators.

From the results of the plate counts, it was quite an alarming finding that the microbiological quality of the equipment and common facilities were highly contaminated as reported by the prevalence of microorganism indicators. This may have been

Table 3. Qualitative Preliminary screening results of 112 samples of galley equipment, safety equipment and cabin common facilities according to the type of flight sectors.

	BKI/KUL		BOM/KUL		LHR/KUL		NRT/KUL		SUB/KUL		Total	
Positive samples	8		21		17		25		29			
Negative samples	6		0		0		5		1			
	+	-	+	-	+	-	+	-	+	-	+	-
Galley equipment (GE)	0	0	6	0	8	0	24	6	19	1	57 (50.89)	7 (6.25)
Service equipment (SE)	0	0	8	0	4	0	0	0	8	0	20 (17.86)	0
Common facilities (CF)	8	6	7	0	5	0	0	0	2	0	22 (19.64)	6 (5.35)
Total	8	6	21	0	17	0	24	6	29	1	99	13

Figures in parentheses indicate the percentage of positive or negative samples. +: positive samples, -: negative samples

Table 4. The preliminary microbial screening results of positive and negative samples by type of inbound flight sectors

Type of surface	Type of inbound flight sectors								
	Long haul		Medium haul		Short haul		Total		
	+	-	+	-	+	-	+	-	
Galley equipment	8 (7.14)	0	30 (26.79)	6 (5.36)	19 (16.96)	1 (0.98)	57 (50.89)	7 (6.25)	64 (57.14)
Safety equipment	4 (3.57)	0	8 (7.14)	0	8 (9.14)	0	20 (17.86)	0	20 (17.86)
Common facilities	5 (4.46)	0	7 (6.25)	0	10 (8.93)	6 (5.36)	22 (19.64)	6 (5.35)	28 (25.00)
Total	17 (15.18)	0	45 (40.18)	6 (5.36)	37 (33.01)	7 (2.15)	99 (88.39)	13 (11.61)	112

Figures in parentheses indicate the percentage of positive or negative samples. +: positive samples, -: negative samples

contributed by a few conducive factors such as the standard ambient temperature of the cabin between 18˚C to 30˚C (Aviation and Cabin Familiarization Manual, 2020) and extended long hours of flight time. Medium and long haul flights create opportune times for the growth of bacteria. A medium flight sector flies between 5 to 8 hrs while a long haul flight would fly beyond 8 hrs flight time. The risk of failing to maintain a food chilling compartment is one of the greatest fears of flight attendants. The longer the flight time the longer the holding time, exposing the food to sources of contamination. Periodical reports on in-flight food contamination had contributed to foodborne illnesses. This did not rule out the potential food poisoning incident caused by spoilage in food and water (McMullan *et al.,* 2001). Consumption of contaminated food by pathogenic bacteria like *Salmonella* Enteriditis (SE) can be deadly. A study case by Ogata *et al.* (2009) found that a passenger died due to consumption of a small piece of food contaminated by *Salmonella* Enteriditis (SE). The classic example demonstrating the devastating consequences of an in-flight food poisoning outbreak was recorded on 3rd February 1975. According to Eisenberg *et al.* (1975), 1 crew member and 344 passengers contracted a gastrointestinal illness which brought 142 of the passengers to the hospital. The investigation reported that *Staphylococcus aureus* and food handlers were the main agents of food contamination.

Coliforms in general indicate the presence of faecal contamination. The primary sources of coliforms are from the animal intestinal tract and the other is from soil vegetation and insects. Unlike most microbiological research that took samples from the commonly regulated environment like school canteens, college cafeterias, restaurants etcetera, the samples for these particular in-flight food safety microbiological analyses were taken from the confinement of aeroplanes that were travelling at 35,000-40,000 feet above sea level. Numerous research have been conducted to assess the microbiological quality of surfaces (Flores *et al.,* 2011; Rodríguez *et al.,* 2011; Garayoa *et al.,* 2016; Tóth *et al.,* 2018; Touimi, *et al.,* 2019; Sibanyoni *et al.,* 2019; Osaili *et al.,* 2020). There were also many studies that quantify the microbiological quality of ready-to-eat foods. While microbial assessment on the surfaces can be performed to determine the effectiveness of cleaning and sanitization, the microbial analysis of ready-to-eat foods can be conducted to determine whether or not the samples used for the testing are contaminated by any selected microorganism indicators (Khater *et al.,* 2013; Syne *et al.,* 2013; Nahar and Mahyudin, 2018; Petruzzelli *et al.,* 2018; Mengistu and Tolera, 2020).

A total 112 surface swab samples have been selectively taken from five different inbound flight sectors. This hands-on study was conducted in reference to a previous study by Crosby *et al*. (2008) in which they assessed the microbiological quality of three food contact surfaces and one non-food contact surface at childcare centres. They chose *E. coli* and coliforms as the bacterium indicators for their microbial assessment. However, in addition, and concurring with their selected bacterium indicators, media for *Vibrio* and *Salmonella* were included as additional microorganism indicators for this microbiological preliminary screening. Even though the results of a preliminary screening were as simple as to categorically notate them as positive or negative samples, this approach was sufficient to determine and describe whether the sampling areas were scientifically contaminated or not. In reference to Table 3 and Table 4, it was reported that the total positive samples from all the five inbound flight sectors selected for the swab sampling were 99 (88.37%). Table 4 showed coliforms were detected as the most prevalent bacteria, 87 or 34.39%. It was found that positive samples from the galley equipment, safety equipment and cabin facility were 64 (57.14%), 20 (17.86%) and 28 (25%), respectively.

The prevalence of *E. coli* in the AMPC suggested faecal contamination from the hands of the flight attendants onto the galley and safety equipment. Flight attendants are known for their multi-tasking ability. When flight attendants clean and replenish the lavatory amenities, it is a common practice for them to open the storage compartment in the lavatory where the amenities are located. By doing so, cross-contamination is made possible because bacteria can live on surfaces, and they are not seen by their naked eyes. This condition appears to be in agreement with findings by Edema and Omemu where they reported that prevalence represents a lack of cleanliness in food handling as well as improper food storage (Edema and Omemu, 2004). The prevalence of microbes is also an indication of possible contamination from passengers' hands because they have open access over the cabin common facilities. As illustrated in Table 5, although the prevalence of *E. coli* and *Vibrio* were at 56 (12.5%) and 49 (10.94%), the coliform contamination proved to have been present at a high 87 (19.42%) of the total plate counts. Concurrently, *Salmonella* was present in 43 (9.6%) of the total plate counts.

Vibrio spp. is mostly marine in origin and its taxonomy is continuously being revised due to the addition of new species (Etinosa *et al.,* 2008), its infection has also been commonly found as foodborne infections in countries within Asia (Sutherland and Varnam, 2000). These bacteria can also be found on

surfaces that may have been contaminated and exposure to the ambient temperature for a long period of time might cause multiplication of microorganisms. *Vibrio* spp. such as *Vibrio cholerae* can possibly cause cross-contamination during the food handling process (Chai *et al*., 2008; Yang *et al*., 2008; Tunung *et al*., 2010). In agreement with the study conducted by Wilks *et al.* (2005), such bacteria as *E. coli* can survive on the surface of steel for a period as long as 28 days in refrigerated and non-refrigerated temperatures. The surfaces of the swab sampling areas taken for this study were no exceptions.

5. Conclusion

Considering the sensitivity of the working environment in the aviation industry, the opportunity to conduct this preliminary microbial analysis was indeed a privilege that was hardly taken to task. This was truly a rare opportunity that contributed to the body of knowledge that befitted the aviation industry. This research fundamentally focused on elementary microbial evaluation. Therefore, the outcome of this microbiological analysis is set as a milestone that may be further improved by other researchers within and outside the industry. The parameters as prescribed in the HACCP management system should be constantly reviewed to include consistent monitoring enforcement to ensure that the critical control points of food safety are not abused. Personal hygiene, which includes correct washing of hands and proper sanitizing of galley equipment is imperative to prevent contamination and cross-contamination. Flight attendants who regularly replenish the lavatories should be more concerned about the sterility of lavatories. To diligently sanitize the touching points and areas such as lavatories, doorknobs, latches, switch buttons, facial mirrors and water faucets should become their habitual practices each time they utilize and replenish the lavatories. The same attitude is required of them when managing other areas of the galley and safety equipment. Therefore, highlighting and creating awareness of the importance of practising good housekeeping, maintaining meticulous personal hygiene practices among the flight attendants are imperative in the course of performing their in-flight duty. Failing to do so may pose a high risk of cross-contamination that potentially lead to food poisoning. Any forms and elements that contribute to food poisoning are health risk parameters that society cannot afford to bear.

Conflict of interest

This study was consented to by the department manager. The due process of collecting swab samples did not in any way interfere with the core duties of the flight attendants. There was no conflict of interest.

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