


# Assessment of food safety conditions at food service premises using Thai survey form and field fecal indicator testing in Pakpoo municipality of Nakhon Si Thammarat, Thailand

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## Abstract

The aim of this descriptive cross-sectional study was to investigate the food safety conditions at food service premises and the hand hygiene of food handlers in Nakhon Si Thammarat, Thailand. The food safety conditions of 24 food service premises in the Pakpoo municipality of Nakhon Si Thammarat were assessed using a food sanitation inspection form and fecal indicator testing. The fecal indicators in this study were coliform bacteria and *Escherichia coli* (*E. coli*). A total of 162 samples were randomly collected from food and utensils and analyzed for coliform contamination. Samples were also obtained from food handlers and analyzed for coliform and *E. coli* contamination. None of the premises achieved the requirements of the Thai food safety standard. The samples showed significant coliform contamination ( $p < 0.01$ ). Notably, the ice and drinking water samples were 100% coliform positive. The highest number of viable cells of total coliform and *E. coli* on the hands of the food handlers were  $>200$  CFU/hand and  $>50$  CFU/hand, respectively. Food safety conditions and food handlers' hand hygiene should be improved to protect consumers from the risk of foodborne diseases.

**Keywords:** coliform, *Escherichia coli*, food safety, food service, hygiene, food safety survey.

**Practical Application:** Improving the food safety conditions of food service premises to reduce foodborne diseases.

## 1 Introduction

Food safety is a global public health priority because 10% of people worldwide get sick from foodborne diseases. More than 400,000 people die each year (World Health Organization, 2021) as a result of consuming food contaminated with bacteria, viruses, parasites, and toxic chemicals. Diarrhea is a common health issue caused by the consumption of food and water contaminated with pathogens such as *Salmonella* spp., *Campylobacter* spp., and enterohaemorrhagic *Escherichia coli* (Centers for Disease Control and Prevention, 2013; World Health Organization, 2021). While most foodborne diseases are caused by the improper preparation or mishandling of food at home, food service premises, or markets, the CDC reported that 50% of foodborne disease cases were associated with food consumption at food premises and noted that food service premises are an important source of foodborne diseases in humans (Gould et al., 2013).

The Department of Disease Control in Thailand reported diarrhea among 716,513 patients (1,095.21 per 100,000 inhabitants) from January to September 2019 (Epidemiology Division, 2019). Several strategies to improve food safety standards have been established in Thailand, among which the Clean Food Good Taste (CFGF) project is one of the most prominent. The CFGF was implemented in 1999 to support tourism, the local economy, and public health (Bureau of Food and Water Sanitation, 2020). Food hygiene at tourism attractions was highlighted as an essential

area of focus in the Second National Tourism Development Plan of Thailand (2017-2021) (The National Tourism Policy Committee, 2017). A CFGF certificate is issued by the BFWS, Department of Health, Ministry of Public Health, following the successful assessment of food service premises. A food sanitation inspection (FSI) form together with microbial indicators for fecal contamination testing are the main tools for food safety surveillance in Thailand (Bureau of Food and Water Sanitation, 2013a). The CFGF annual report by the BFWS in 2018 showed that, while 85.3% of food service premises achieved the required standard, the number of patients with diarrhea remained high (Bureau of Food and Water Sanitation, 2018). Several factors are involved in preventing foodborne diseases, from poor food safety to the personal hygiene of consumers and food handlers (Kibret & Abera, 2012; Wambui et al., 2017).

The southern part of Thailand is composed of 14 provinces and is considered outstanding for its tourist attractions and the variety of food on offer. Nakhon Si Thammarat (NST) is the most popular province in the southern part of Thailand. According to the CFGF report in 2018, the NST achieved the lowest percentage for Thai food safety standards in the south (Bureau of Food and Water Sanitation, 2018). In the same year, the diarrhea morbidity rate in NST was 5,991.8 people per 100,000 inhabitants (Health Data Center, 2020). This is concerning because food safety is

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a significant requirement to build consumer confidence and protect the health of consumers (Suphaphon & Agmapisarn, 2019). Pakpooon municipality is one of the significant areas in the Mueang Nakhon Si Thammarat District, which is the capital district and commercial and economic center of NST. In addition to being a transportation route and tourist stopover, Pakpooon municipality is the location of various important facilities, such as an airport, high schools, military camps, and attractive tourist venues. Notably, Pakpooon municipality has many food service businesses, ranging from large food premises to street food stalls.

Food safety is important for foodborne disease prevention and control and to build confidence in food safety measures among consumers, tourists, and the general population (Aksoydan, 2007; Kibret & Abera, 2012). This study therefore aimed to investigate the food safety conditions at food service premises and the hand hygiene of food handlers in Pakpooon municipality, Nakhon Si Thammarat, Thailand, to help reduce health risks from foodborne diseases.

## 2 Materials and methods

### 2.1 Study area

The study was conducted in the Pakpooon municipality, which is one of the important subdistricts of Mueang Nakhon Si Thammarat District (Figure 1). In 2016–2020, the diarrhea

morbidity rate of Pakpooon municipality was the highest among the subdistricts in Mueang Nakhon Si Thammarat District.

### 2.2 Study participants

This descriptive cross-sectional study was conducted at food service premises in Pakpooon municipality from August to October 2018. All the food service premises ( $n = 24$ ) registered with the local authority in Pakpooon municipality were included in this study, while other types of food services, such as food delivery services and food stalls, were excluded. Registered food service premises that were in the process of renewing their permits were also included. Purposive sampling was applied, and samples were collected from food handlers, food, and kitchen utensils for fecal indicator testing.

### 2.3 Food safety survey

The survey was performed in line with the CFGT standard, which consists of two components: (1) a food sanitation inspection using the FSI form and (2) coliform bacterial testing of food, utensils, and food handlers' hands using the coliform bacteria screening kit (SI-2) developed by the Research and Laboratory Development Center, Department of Health, Thailand. The food handlers' hands were also enumerated for *Escherichia coli* (*E. coli*) using 3M<sup>®</sup> Petrifilm<sup>™</sup> *E. coli*/Coliforms Count (EC) Plates (Canada), which is an additional test included in the CFGT

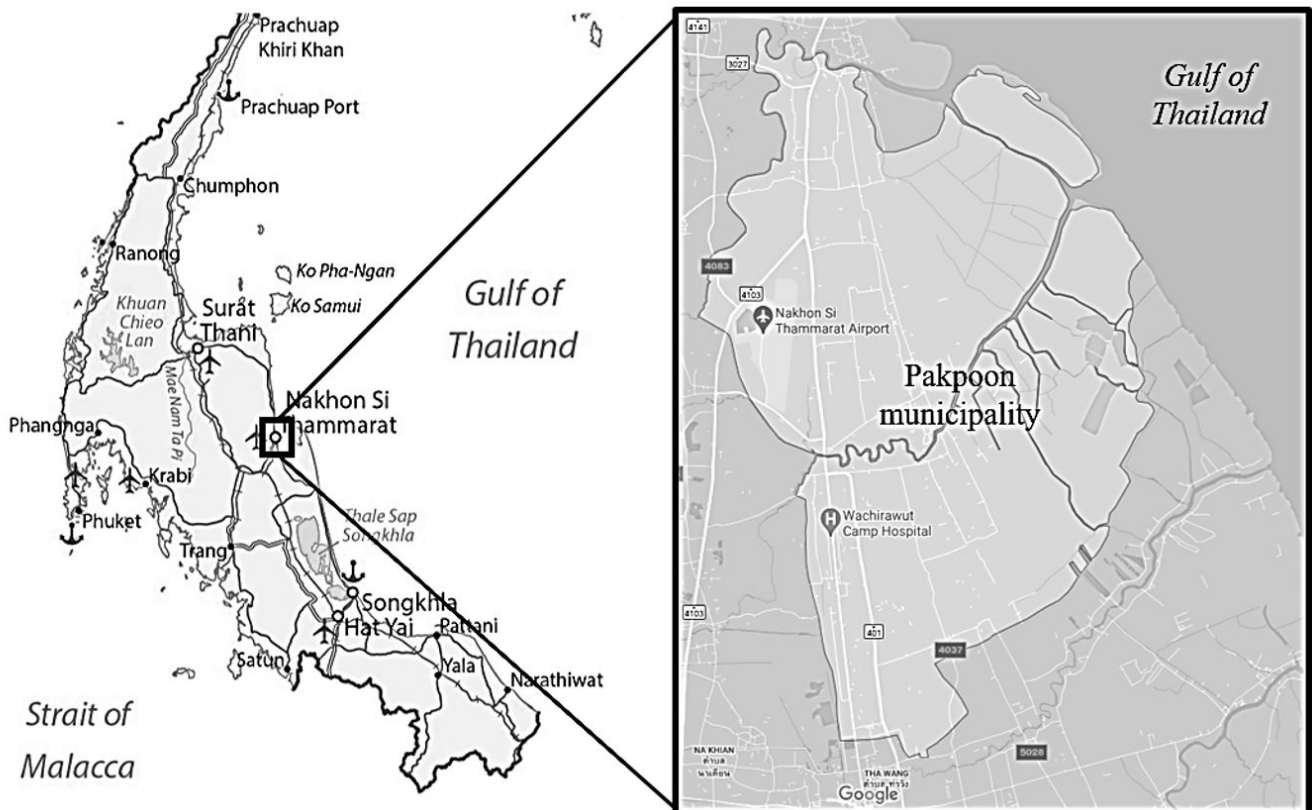


Figure 1. The study area (GISGeography, 2021; Google, 2021).

standard. The survey was conducted by researchers and assistant researchers who had received training on the survey and microbial analysis techniques.

#### 2.4 Food sanitation inspection

The FSI form consists of five categories, namely, (1) preparation and cooking area, (2) food, (3) utensils, (4) sanitation, and (5) food handlers, with 15 criteria in total. Using the BFWS criteria, the food service premises assessment results were categorized as “satisfactory,” “unsatisfactory,” and “no activity” (Bureau of Food and Water Sanitation, 2013a).

#### 2.5 Coliform bacterial testing

The food, utensils, and food handlers were examined for coliform contamination. The coliform bacteria from the three sample types were analyzed using the SI-2 in accordance with the manufacturer’s instructions. The sampling protocol was performed by following the BFWS guidelines and included five food samples, three utensil samples, and two food handler samples (chef and waiter) from each premises. The samples were collected by quota sampling. The surfaces of the utensils and the food handlers’ hands were swabbed for fecal indicator testing using a sterile cotton swab and an aseptic technique, while the food samples were mixed directly with the SI-2 (Bureau of Food and Water Sanitation, 2013a).

#### 2.6 Isolation and enumeration of *E. coli*

To swab the food handlers’ hands for *E. Coli*, a sterile cotton swab was applied using an aseptic technique. The cotton swab was then placed in a 10 mL sterile buffer tube, and the screw cap was closed tightly (Bureau of Quality and Safety of Food, 2017). The tube was gently shaken for 30 seconds, and 1 mL of buffer was pipetted to the EC plates (3M<sup>™</sup> Petrifilm<sup>™</sup>, Canada) according to the manufacturer’s instructions for fecal bacteria detection. The blue colonies with gas were measured and recorded as *E. coli* positive at room temperature (25–37 °C) for 17–24 hours.

#### 2.7 Data analysis

The inspection data and fecal indicator testing were analyzed using descriptive statistics (frequency and percentage). The association between the types of samples, food service premises, roles of the food handlers, and bacterial contamination were analyzed using a chi-square ( $\chi^2$ ) test with a 95% confidence level ( $\alpha < 0.05$ ).

#### 2.8 Ethics statement

Ethical approval for this study was obtained from the Walailak University Ethics Committee (WUEC-19-207-01). Informed consent were obtained from the participants before collecting the data. The research procedures complied with the EC standard of Walailak University.

### 3 Results

#### 3.1 Food sanitation inspection

Twenty-four food service premises in Pakpoo municipality, Nakhon Si Thammarat, Thailand, were included in this study, among them, 16 (66.7%) savory food premises (cooked-to-order, curry, and ready-to-eat premises) and eight (33.3%) sweet and beverage premises. The food service premises in the study met the requirements of nine of the 15 criteria (Table 1). However, the BFWS standard indicates that the assessment results should be satisfactory for all the criteria of the food sanitation inspection. Six premises (four savory food premises and two sweet and beverage premises) were found to be unsatisfactory. Although they met the criteria for all utensils, the toilet facilities in these premises were the most critical issue as they lacked sinks and soap for handwashing. The food additives used in all the food service premises had been certified by the Food and Drug Administration, Ministry of Public Health, Thailand. The fresh and cooked foods also met the standard, which requires suitable washing and storage facilities. In total, 18 premises (75%) achieved the required standards of the food sanitation inspection.

#### 3.2 Coliform bacterial testing

In total, 70 (39.6%), 65 (36.7%), and 42 (23.7%) food, utensil, and food handler samples, respectively, were collected for coliform bacterial testing using the SI-2. The amount of each sample type obtained was determined by its availability and the context of the food service premises. Overall, the results of the coliform bacterial testing showed that the utensils had the highest negative results, followed by the food handler and food samples (Table 2). The highest rate of contamination was found in the ice and drinking water samples, which showed 100% positive results (Figure 2A). The results indicated that none of the food service premises had satisfactory levels of hygiene with respect to coliform contamination because 10% of the samples at each premises exceeded the CFGT standard. Accordingly, none of the premises achieved the CFGT standard for certification.

#### 3.3 *E. coli* enumeration of the food handlers

Twenty-eight food handlers’ hands which obtained positive results of SI-2 were assessed for *E. coli* contamination. The samples from two food handlers from savory food premises and two from sweet and beverage premises showed blue colonies with gas on the EC plates. *E. coli* was detected on 14.3% (4/28) of the food handlers’ hands, accounting for 16.7% of all the chefs and 10% of all the waiters. The *E. coli* counts on the EC plates were 1–50 (5.6%) and 51–100 (11.1%) CFU/hand for the chefs and 1–50 CFU/hand (10.0%) for the waiters (Figure 2B).

#### 3.4 Relationship between the sample types and coliform

The associations between the sample types, food service premises, roles of the food handlers, and bacterial contamination were analyzed using a chi-square ( $\chi^2$ ) test with a 95% confidence interval. The results showed that food, utensils, and food handlers

**Table 1.** Results of the food sanitation inspection using the food sanitation inspection form (n = 24).

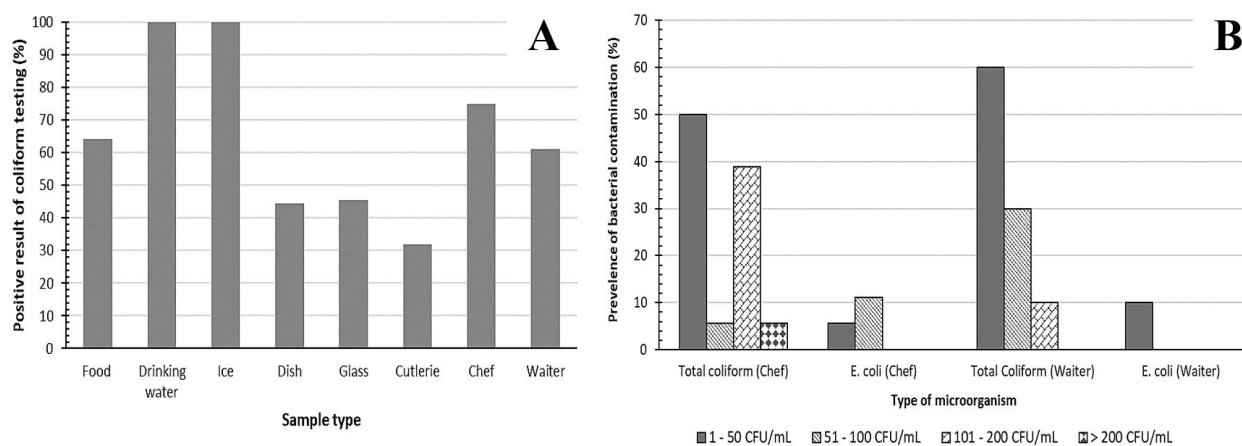
| Food sanitation inspection criteria for food service premises  | Results <sup>a</sup> |           |           |
|--|----------------------|-----------|-----------|
|  | S                    | U         | N/A       |
| <b>1. Preparation and cooking area</b>   |                      |           |           |
| Cleanliness and proper of the service area   | 22 (91.7%)           | 2 (8.3%)  | 0         |
| Suitability of the prepared and cooked food processes  | 24 (100%)            | 0         | 0         |
| <b>2. Food</b>   |                      |           |           |
| Compliance with the food additives standard  | 24 (100%)            | 0         | 0         |
| Washing and storage of fresh food  | 22 (91.7%)           | 0         | 2 (8.3%)  |
| Covering and storage of cooked food  | 24 (100%)            | 0         | 0         |
| Covered containers and proper utensils for edible ice  | 21 (87.5%)           | 2 (8.3%)  | 1 (4.2%)  |
| <b>3. Utensils</b>   |                      |           |           |
| Suitable sink and washing facilities for utensils  | 24 (100%)            | 0         | 0         |
| Suitable cutting boards and knives   | 20 (83.3%)           | 0         | 4 (16.7%) |
| Suitable containers for, and storage of, cutlery   | 23 (95.8%)           | 0         | 1 (4.2%)  |
| <b>4. Sanitation</b>   |                      |           |           |
| Suitable food waste and wastewater disposal  | 22 (91.7%)           | 2 (8.3%)  | 0         |
| Suitable and adequate toilets  | 14 (58.3%)           | 6 (25.0%) | 4 (16.7%) |
| <b>5. Food handlers</b>  |                      |           |           |
| Suitable protective clothing for food handlers   | 22 (91.7%)           | 2 (8.3%)  | 0         |
| Suitable handwashing by food handlers  | 24 (100%)            | 0         | 0         |
| Suitable protection of cuts or wounds of food handlers   | 24 (100%)            | 0         | 0         |
| Adequate recovery of food handlers who suffer from or are carriers of any disease transmittable via water and/or food before service | 23 (95.8%)           | 1 (4.2%)  | 0         |

<sup>a</sup>The results indicate the percentages calculated from 24 food service premises. N/A, no activity; S, satisfactory; U, unsatisfactory.

**Table 2.** The relationships between the sample types and the roles of the food handlers and the coliform bacteria results calculated using a chi-square ( $\chi^2$ ) test.

| Variables                           | Number with contamination (%) |            | p-value |
|-------------------------------------|-------------------------------|------------|---------|
|                                     | Positive                      | Negative   |         |
| <b>Sample types</b>                 |                               |            |         |
| Food (n = 70) <sup>a</sup>          | 55 (78.6%)                    | 15 (21.4%) | 0.000   |
| Utensils (n = 65) <sup>b</sup>      | 26 (40.0%)                    | 39 (60.0%) |         |
| Food handlers (n = 42) <sup>c</sup> | 29 (69.0%)                    | 13 (31.0%) |         |
| <b>Food handler roles</b>           |                               |            |         |
| Chefs (n = 24)                      | 18 (75.0%)                    | 6 (25.0%)  | 0.335   |
| Waiters (n = 18)                    | 11 (61.1%)                    | 7 (38.9%)  |         |

<sup>a</sup>Food included food, drinking water, and ice; <sup>b</sup>Utensils included dishes, glassware, and cutlery; <sup>c</sup>Food handlers included chefs and waiters.

**Figure 2.** Results of the fecal indicator testing: (A) Positive results of coliform bacterial testing (%) using the SI-2 of each sample, and (B) the prevalence of coliform and *E. coli* contamination (CFU/hand) among the chefs and waiters using EC plates (3M™ Petrifilm™) (%).

were significantly associated with coliform bacteria ( $p < 0.01$ ), while the roles of the food handlers were not, as shown in Table 2.

#### 4 Discussion

To meet the minimum requirements of the CFGT standard, all the food premises assessed in this study should have complied; however, none of the 24 (100%) food service premises in the Pakpoo municipality in the study achieved the CFGT standard because the coliform bacteria detection rate exceeded the standard set by the BFWS, Department of Health, Ministry of Public Health, Thailand. This low CFGT achievement rate was similar to that of a study in Phitsanulok province, Thailand, in which a rate of 1.1% was achieved (Srisai & Yasaka, 2016). In contrast, the food sanitation inspection in this study was highly satisfactory (up to 75%). This finding is consistent with the results of studies in NST and Pattani, which showed high achievement rates of 71.3% and 64.6%, respectively (Meewassana et al., 2016; Veerapun & Thongkum, 2007). Similarly to the present research, these studies also revealed high coliform contamination. Both NST and Pattani are located in the south of Thailand and have a comparably warm climate, so the temperature could contribute to coliform growth. Although the levels of food sanitation at all the premises met the CGFT criteria, the results did not guarantee that all the food, utensils, and food handlers were free of coliform and *E. coli* contamination. Several studies have shown a significant relationship between pathogen contamination and the hygiene of food service premises and cross-contamination (Elson et al., 2004; Gorman et al., 2002; Kibret & Abera, 2012; Mazengia et al., 2015; Vindigni et al., 2007). To reduce the risk to human health through coliform, *E. coli*, and other Enterobacteriaceae contamination in food, food sanitation inspections must be carried out and the standards complied with continually.

The critical issues identified in the food sanitation inspection as needing improvement were cleanliness and the appropriateness of the service areas, edible ice, food waste and wastewater management, sanitary facilities in the toilet(s), protective clothing (aprons and hair nets), and disease prevention and control among food handlers. Similar findings were reported by Jongsamak et al. (2014) and Veerapun & Thongkum (2007), who found that improper utensils were used with edible ice, and other substances such as bottles, vegetables, and raw materials were present in ice containers. The unsanitary disposal systems for solid waste and wastewater account for one-third of the problems in food service premises in many provinces in Thailand. The unsanitary disposal methods identified in this study were uncovered trash and leachate leakage, which could be a breeding site and food source for vectors such as flies and rodents. Unsanitary toilets were also an extensive problem noted during the food sanitation inspections in this study. The same issue was described in the findings of previous studies (Srisai & Yasaka, 2016; Veerapun & Thongkum, 2007). The unhygienic conditions of toilets and the lack of sanitary facilities such as toilet paper and soap or alcohol hand sanitizer in toilets could increase the risk of bacterial contamination of food and utensils via food handlers and consumers. Several studies have revealed the prevalence of coliform bacteria and pathogens on the surfaces of toilet facilities, which could be a significant source of foodborne illness

transmission from consumers and food handlers' hands to food (Chitpirom, 2013; Nworie et al., 2012). In addition, the food handlers in the present study did not wear hairnets, and their aprons were not clean, so hair and/or microorganisms could be a source of further contamination. Entrepreneurs should therefore perform strict food safety practices in line with the BFWS of Thailand guidelines to prevent adverse health effects on consumers.

Some behaviors and practices that are missing from the FSI form may influence coliform and *E. coli* contamination. However, the CFGT standard includes both coliform bacterial testing and food sanitation inspections to increase the efficiency of the surveillance system. Coliform bacteria are an important group in the family Enterobacteriaceae and are one of the essential indicators in food sanitation inspections of food service premises. The SI-2 is widely used to screen for coliform bacteria as part of the food safety surveillance in Thailand (Kongpran et al., 2021). The SI-2, which was developed by the Department of Health, Thailand, is the field test kit for screening for coliform in food. The SI-2 medium contains lactose broth with bromocresol purple as an indicator. Theoretically, coliform bacteria can ferment lactose with the production of acid and gas at 35–37°C (Patel et al., 2014). The acidification of the medium causes the pH indicator bromocresol purple to change the color of the medium from purple to yellow, which indicates the presence of coliform. This test kit shows high efficiency, is inexpensive, and produces results for interpretation quickly (Bureau of Food and Water Sanitation, 2013b).

In this study, the highest coliform bacteria contamination was detected in food, followed by food handlers and utensils. Cross-contamination from food handlers and utensils leads to coliform contamination in food (Gorman et al., 2002; Mazengia et al., 2015). Edible ice and drinking water had the highest rate (100%) of coliform contamination among the food samples in the present study. This finding is similar to those of studies in Nakhon Pathom and Samut Sakhon provinces where the total coliform bacteria detected in ice samples was 100% and 53.0%, respectively (Jongsamak et al., 2014; Sirichokchatchawan & Somrongthong, 2020). Likewise, Yodmanee et al. (2012) found that 92.5% and 57.5% of the ice in three provinces in the lower south region of Thailand were contaminated with coliform and *E. coli* at higher rates than those stipulated in the Notification of the Ministry of Public Health, Edition 78 (1984). The researchers reported that size of edible ice, water quality, ice machines, ice scoops, containers, and food handlers' hygiene affected ice contamination. In the current study, 69% of the food handlers were found to have coliform contamination on their hands, and 40% of the utensils were contaminated. A high coliform contamination rate among food handlers in food service premises was also found in previous studies in NST (75.5%) and Phitsanulok (54.0% and 61.0%), with utensil contamination also present in these provinces (NST, 56.3%; Phitsanulok, 49.0% and 47.0%) (Meewassana et al., 2016; Perathornich et al., 2015; Srisai & Yasaka, 2016).

Although the results of the food sanitation inspections in this study were satisfactory at 66.7%, the tests for coliform bacteria were 100% positive. Other issues not included in the FSI

checklist could influence bacterial contamination. For example, the cleanliness of doorknobs and water taps in toilet facilities are not mentioned. Doorknobs and water taps are often ignored during the cleaning of most premises; however, these can become contaminated and result in the accumulation of bacteria, which can be conveyed to the hands of food handlers and consumers through contact with these items (Chitpirom, 2013; Nworie et al., 2012). Another critical issue is towels that are used to wipe hands, dishes, and tables repeatedly without cleaning. Such microorganism contamination could have been present in almost all the food service premises in this study. Previous studies have reported that towels, especially cloth towels, were used multiple times and could accumulate microorganisms, with these microorganisms then spreading to food handlers' hands, utensils, tables, and food-related areas (Cogan et al., 2002; Gerba et al., 2014; Sneed et al., 2015). Gerba et al. (2014) recommended that towels be washed often as this could significantly reduce the amount of *E. coli* present.

The total coliform numbers on food handlers' hands were satisfactory based on the microbiology criteria of food handlers in Thailand, which indicate that total coliform on food handler's hands must be less than 500 CFU/hand. Notwithstanding, the Thai food safety standard states that *E. coli* must not be detected on food handlers' hands (Bureau of Quality and Safety of Food, 2017). In this study, four food handlers were found to have *E. coli* contamination, so their personal hygiene should be improved to reduce the risk of foodborne diseases.

This study showed that the types of food and utensils were not related to the presence of coliform because coliform was found on all the sample types, especially the edible ice samples. This result is in contrast to the results of a previous study in Thailand, which found a significant difference in coliform contamination among different types of food ( $p < 0.001$ ) (Perathornich et al., 2015). The association analysis in this study found that the roles of food handlers were not related to the prevalence of coliform bacteria, while a significant association was found among food, utensils, and food handlers. Food had the highest risk of contamination because both utensils and food handlers can contaminate food.

## 5 Conclusion

The results of the food sanitation inspections did not relate to coliform contamination. Food was found to have the highest positive rate for coliform compared to utensils and food handlers' hands. Moreover, *E. coli* was detected on food handlers' hands. Food sanitation measures, as well as the hygiene of food handlers, play an important role in the prevention and control of food-borne diseases.

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